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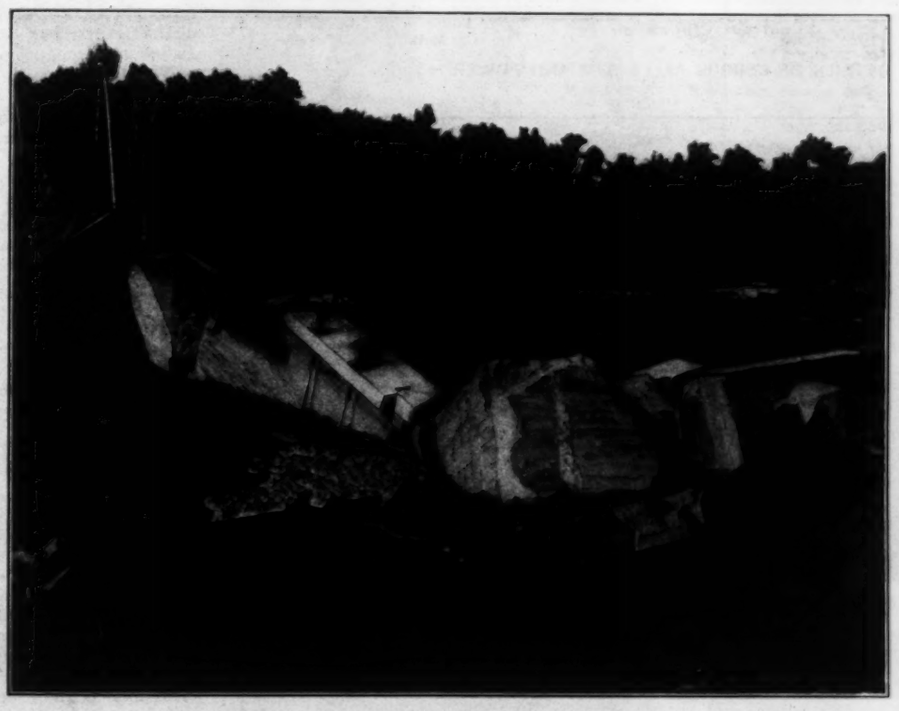
The Failure of the Fergus Falls, Minn., City Dam.

By FRANKLIN McMILLAN.*

In Engineering News of last week (Oct. 7, 1909, p. 391) brief notice was made of the failure of a concrete dam at Fergus Falls, Minn., on Sept. 24, the consequent collapse of four other dams down-stream and the partial wrecking of a bridge, all due to the flood-crest following the initial collapse. At the request of Engineering News the writer visited the site of the flood and has prepared the following account of the construction and failure of the dam.

The City Dam, storing water for a municipally owned electric lighting plant, was situated on the Red River of the North, about three miles above the city of Fergus Falls. The foundation was put in in the fall of 1907, but a suspension of the contract left the balance of the work to be completed under a new contract during the summer of 1908. The plant, then, had been in operation only about 11 months at the time of its destruction. Only one 250-KW. turbine generator unit had been installed, but there was space for a second one of the same capacity. The accompanying drawing, Fig. 2, shows the principal dimensions and the general arrangement of the plant. This is further illustrated by the half-tones shown in Figs. 3 and 4.



WRECK OF THE CITY DAM AND POWER HOUSE, FERGUS FALLS, MINN.

The engineer in charge of the design and construction, Mr. R. S. Feurtado, had borings made in the river bed at the dam site before construction commenced and reported that he encountered 4 ft. of sand and gravel forming the bed of the stream, below this 3 ft. of sand and clay mixed, then 4 ft. of blue clay and below that a "mixture of clay and gravel known as hardpan," into which he thought it unnecessary to bore more than 3 ft. His report recommended the building of the dam at this site, as he considered it a good foundation. During the excavation of the foundations numerous small springs were encountered, coming through crater-like openings and forming small mounds of sand. With the exception of one, these had disappeared before the excavation was finally complete. But on account of the character of the material encountered it was decided to carry the footings of the spillway section down to the same elevation as the bottom of the wheel pit. This added 5 ft. to the depth originally planned for this part of the structure. This change is noted in Fig. 2. The one spring which had not disappeared continued to give trouble up to the time of placing of the concrete base in the tailrace, and it is reported that considerable difficulty was encountered in stopping this sufficiently to permit the concrete to set. What means were adopted to accomplish this the writer was unable to learn. This spring was located at about the point marked X in Fig. 2. It has also been stated by parties familiar with the general condition under which the work was carried on that the borings were very unsatisfactory and the conclusions drawn from them very unreliable.

The clay deposits in the vicinity of the dam usually contain a large percentage of sand and when saturated and subject to disturbances become very plastic and unstable.

Since the dam was put in operation a small leak was discovered through the embankment core wall on the side of the river opposite to the power-house, but this was successfully stopped and gave no further trouble. A spring did open up just back of the power-house and below the core wall, and the water from it was used for drinking. It flowed about a gallon in five minutes. The only other irregularity that was noticed was that one sluice gate never closed completely, and there was always a discharge through this small opening.

The dam failed at 4.30 a. m., Sept. 24, 1909, with but a minute's warning, giving the operator on shift and the day man sleeping in the building barely time to get to a place of safety before the entire plant was a complete wreck. The first sign of trouble was a flickering of the lights and a change in the sound of the running machinery. The tailrace for the unit in operation was discovered to be running full, while the water in the other tailrace and in the main river channel was at about its normal stage, some 5 or 6 ft. lower. The water was spouting through a drain opening in the floor, when the men left the building, and when but a few feet out of danger the entire building collapsed.

A study of the half-tones shown herewith will show that failure must have resulted from a settling in the vicinity of the junction of the wasteway with the power-house. Until the water is diverted and a study of the lower footings and foundation can be made, it is difficult to make an exact explanation of how the failure occurred. But the tailrace nearest the river (the one in operation) being filled with water so suddenly while the remaining passages were at about normal stage seems to indicate that an opening first developed into this passage.

The possible weakness over the spring at X may have been the cause. The absence of toe walls or any irregularities in the bottom to retard a seepage under this portion of the dam would explain the suddenness of failure after once a communication had been established through the sand-bearing clay. The fracture formed in the spillway, about 36 ft. from the south abutment, shown so clearly in the pictures, plainly indicates a failure by settling at the power-house end. This detached part of the dam as well as the up-stream face of the power-house dam section are both washed a few feet out of parallel to their original location.

A very noticeable effect on the concrete is a shearing apart of large masses along horizontal planes which appeared to form the boundaries

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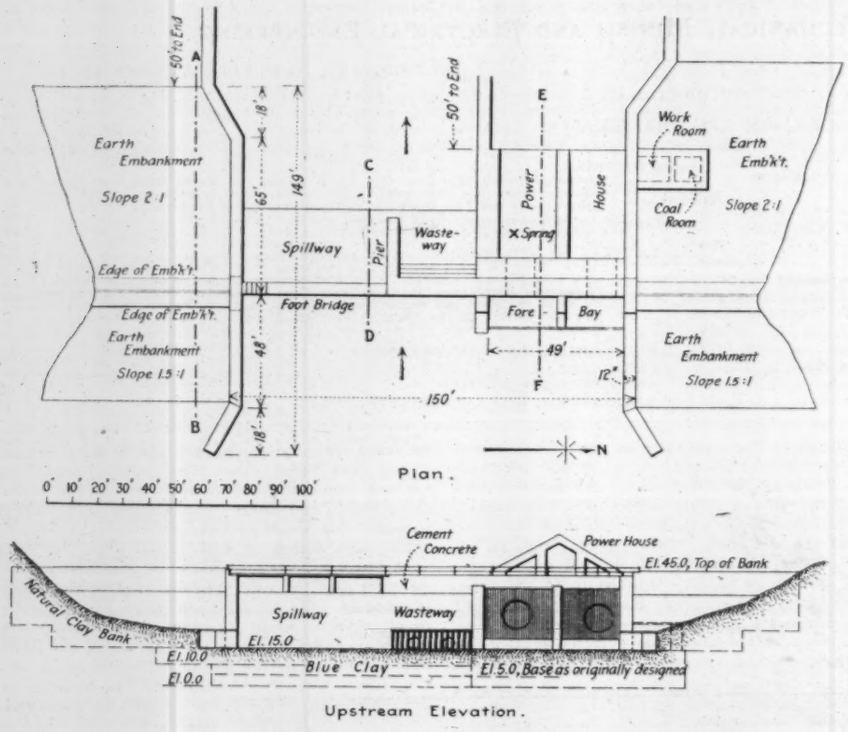

FIG. 2. DETAILS OF FERGUS FALLS DAM AND POWER HOUSE.

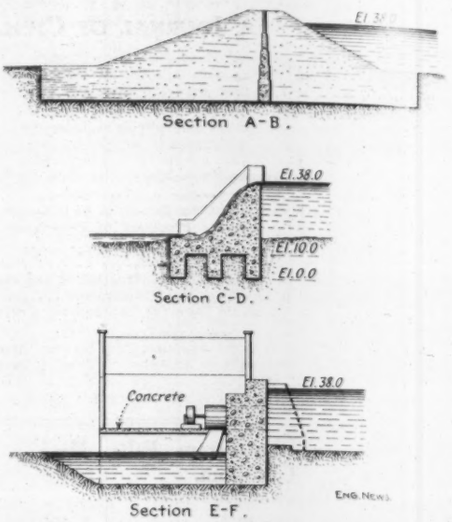

Fig. 3.

Fig. 4.

FIGS. 3 AND 4. VIEWS OF THE FERGUS FALLS POWER HOUSE AND DAM ABOUT THE TIME OF ITS COMPLETION.

of successive days' work. This occurred in a number of places, when the concrete in both layers was of fairly good quality. The concrete generally could be described as fairly good, and suitable for the work. The fractured section of the spillway shows a good dense mixture of uniform quality, but with the successive layers very distinctly marked. The quality of the concrete in the heavy walls at the sides of the powerhouse was not good, being rather porous. The aggregate used was a sand and gravel taken from the hillsides close by, and seems to have given a quite uniform grade of concrete generally.

The Red River of the North has a flow variously estimated from 300 to 1,200 cu. ft. per sec. At the time of the collapse it was not nearly at the maximum. As it passes in its upper course through a series of lakes which act as reservoirs it is not subject to severe floods, which may account for the light design of some of the dams injured by the rush of water following the collapse of the City Dam. These dams, and the bridge below, which were more or less damaged, are as follows in their order on the river:

1 Collapsed Lighting Plant Dam (destroyed), 3 miles above city.
2 Water-Works Dam (injured), 1½ miles above city.
3 Vernon Wright Dam (injured), at city.
4 Mill St. Bridge (injured), at city.
5 Red River Milling Co. Dam (injured), 2 blocks below.
6 Woolen Mill Dam (destroyed), ¼ mile below city.
7 Dayton Hollow Dam (intact), 6 miles below city.

Of these structures it will be seen that only the last passed the flood without damage. This was not injured in any way, as the people in charge were notified in time to permit of lowering the level of the mill pond 5 ins. before the flood arrived. The maximum height to which the flood was over this dam was only 2 ins. above the level at the time the sluicegates were opened. This dam is the property of private parties and is used for development of electric power. The city will be able to get light from the plant within a few days. The second dam to be damaged furnished power for the city water supply. The auxiliary steam plant at the pumping station was soon put in operation and prevented an interruption of the water supply. The third, fourth and fifth dams were used for commercial purposes, supplying power for several flour mills, a woolen mill and other manufacturing enterprises. Work on repairing two of these (Nos. 3 and 5) is already under way, and auxiliary steam plants and portable engines are being utilized to resume manufacturing. In none of the four lower dams was the destruction complete. Such damage as was done was due to the unusual height to which the flood rose, causing the water to pass over the earthen flanking embankments beyond the limits of the dams proper and thus cut channels around the ends of the dam structures. In the case of

the last dam destroyed the wash around the ends was so bad as to practically require a rebuilding of the dam. These four dams were very old, rock-filled cribs, with the exception of the water-power dam, the property of the city, which had a solid masonry mid-river section between cribs, one of which formed the spillway.

A reinforced-concrete arch bridge at Mill St., Fergus Falls, was seriously threatened by the current striking directly upon and back of one of the abutments. About 5 ft. in width of foundation was washed out at this place, resulting in this corner settling nearly an inch. A crack ⅜-in wide extending from about the center of the abutment longitudinally along the underside of the arch to about the center of the span, and two vertical cracks in the retaining wall back of the abutment are the only cracks developed.

Fig. 5. Looking South.

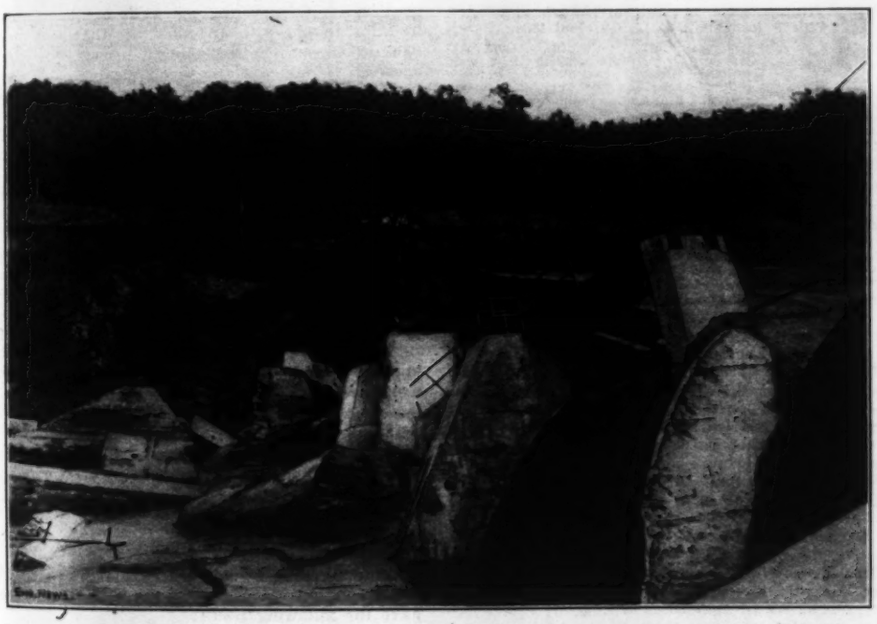

Fig. 6. Looking North.

FIGS. 5 AND 6. ADDITIONAL VIEWS OF THE WRECKED DAM.

CLEVELAND'S LONG STREET RAILWAY CONTROVERSY is at last settled after eight years of controversy. The street railway corporation is to receive a 25-year franchise revokable at any time any part of the contract with the city is violated. The maximum rate of fare is to be so fixed as to earn 6% on the actual value of the property, according to an appraisal to be made by Judge Robert W. Taylor of the U. S. Court. The city reserves the right to name a purchaser for the property at the end of eight years. The initial rate of fare is to be 3 cts. with an extra 1 ct. for a transfer. The terms of the settlement will be submitted to a referendum vote for final ratification.

The Cost of Clearing Water in Settling Basins.*

By S. BENT RUSSELL,† M. Am. Soc. C. E.

We find that the settling basin may not readily be dispensed with, in preparing surface waters for municipal use. In many cases the settling basin seems to be in competition with filtration as a means of making city water satisfactory. In other cases we find the settling basin an important part of the modern filtration plant. Moreover, in mechanical filter plants the tendency seems to be that more work shall be done in the settling basin and less in the filter. This brings up a desire for more information as to the cost of treating water by the simple method of settling.

We find, however, that it is not easy to formulate rules for estimating the cost of settling water. The cost of pumping and of filtering water may be estimated when the quantity and lift are known. The cost of settling basins, however, would seem to depend more upon local conditions. In this paper your attention is directed to the factors that enter into the cost of settling water and certain data from existing water-works will be given that will be of assistance perhaps in making rough preliminary estimates.

In the general problem before us we have, besides the factors that enter into the cost of settling proper, the dependent factors, loss of head and repumping. We must also consider certain balancing advantages attendant upon repumping, etc.

When a river is the source of supply the use of settling basins usually involves repumping the entire quantity of water as it is more economical to have the basins near the intake. In some cases the two pumpings may be at one combined plant, but it will often be better to have two pumping plants connected by a low pressure or gravity conduit. The saving on the conduit will go to make up for the duplication of pumping plant. If a loss of head is allowed in the basins, they can be used for storage. This will give an advantage in case of damage to the intake or of ice stopping the supply. Moreover, when basins at the intake are used, high-pressure engines can be more favorably placed for economical maintenance, and we may note here that pump valves for high pressure will last longer with settled water. Another important saving is from keeping mud and grit out of our pump mains and distribution pipes and meters, and this saving should offset part of the cost of settling the water.

If the settling is to be followed by filtration, we find a saving both in first cost and in operation of the filters as a result of the sedimentation in a large majority of cases. In small plants it may be desirable to run the river pumps only part of the time each day. In such a case basins for combined settling and storage will be profitable.

Let us suppose that we have a river pumping station and a high pressure pumping plant supplying the town, so connected that settling basins may without complication be placed between them. How much will our expenses be increased by the improvement? Although our problem is now greatly simplified, we still find it quite a complicated one and determined by local conditions. The daily quantity to be handled and its rate of increase, and the character and amount of the sediment are important. The kind of soil and rock, climatic and flood conditions, drainage, kind of building material available, cost of land, etc., must be considered. The operating organization of the water-works and financial conditions must be reckoned with. We must know whether coagulants are to be used or not. A coagulating plant may be considered as auxiliary to the settling basins.

We may assume that the basins can be operated with or without loss of head and consequent extra lift by the pumping engines. The cost of settling may be divided into the following items: Interest, depreciation, repairs, operation, clearing, increased lift, pumping cleaning water, coagulating, pumping for coagulating plant, and ground rent. The item of coagulating may, of course, be subdivided into similar heads.

Let us take up some of the above items separately. Interest on first cost will usually be the most important item. Four types of settling reservoirs may be considered: (I.) basins formed by damming a natural valley; (II.) earth embankment basins; (III.) masonry walled basins; (IV.) covered reservoirs.

Reservoirs built for settling will usually cost somewhat more than service reservoirs of the same capacity and type on account of provisions for cleaning and special connections and for baffle walls, weirs, etc. The cost of service and storage reservoirs, however, may be taken as a guide. Table I. gives the cost of a number of reservoirs and the cost per million gallons capacity. The Sudbury reservoirs are included as a matter of interest although they are not paved and are not of a type that could be used for large proportions of sediment. A covered reservoir is also given although settling basins will seldom need to be covered.

At a meeting of the British Association of Water-Works Engineers some years ago, Mr. W. Ingham (see files of water and gas reviews) stated that a covered reservoir of 300,000 gals. capacity had been built for £5 10s. per 1,000 gals. capacity. This would in our units be about $22,900 per million U. S. gals. Mr. Ingham also gave the following analysis of the cost of reservoirs:

OPEN RESERVOIRS:	
Excavation	15% of total cost
Floors	35% " " "
Walls	50% " " "
COVERED RESERVOIRS:	
Excavation	10% of total cost
Floors	24% " " "
Walls	28% " " "
Roof	38% " " "

While discussing the first cost let us anticipate a bit and assume that the total charges for running a system of basins is 8% of the first cost. Then if the basins cost $1,000 per million gallons' capacity, the expenses would be $\frac{1{,}000 \times 8}{100 \times 365} = \$0.219$ per million per day, i. e., a million gallons can be stored one day for 21.9 cts. If the basins cost $5,000 per million gals. the storage costs $1.095; if the cost is $10,000, it costs $2.19 per million gallons per day.

The item of depreciation is dependent on the life of the plant. Now a reservoir is like a baby's shoe—it is usually outgrown before it is out-worn. As a basis for depreciation we must estimate how long the reservoir will prove useful to the municipality.

Repairs should be but a small item. Large repair bills usually point to faulty construction.

The cost of operating depends in some degree upon the size of the plant and upon the quantity of water passing through. The cost should be greater with intermittent flow than with constant flow. In many plants this cost will be inconsiderable.

The cost of cleaning is dependent upon the quantity of water handled and the proportion of sediment removed. The area, or dimensions, of the floors will influence the cost. The inclination of floors and drains, etc., are important factors, and the character of the sediment must be considered. This item is of some importance, where there is much sediment, and to keep this cost within

*From a paper before the convention of the Central States Water Works Association, Columbus, Ohio, Sept. 28.

†Consulting Engineer, 415 Locust St., St. Louis, Mo.

TABLE I.—COST OF RESERVOIRS.

	Class.	No. of basins.	Total capacity, million gals.	Cost.	Cost per million gals. capacity.	
Boston, Sudbury, No. 2	I.	1	530	$71,472	$135	
Boston, Sudbury, No. 4	I.	1	1,400	813,846	570	Soil stripped.
Boston, Sudbury, No. 6	I.	1	1,530	910,300	600	Soil stripped.
Cincinnati	I.	2	330	1,276,000	3,865	Settling.
Harrisburg, Pa.	II.	1	4	21,485	5,371	Settling.
Minneapolis, Minn.	II.	2	93	442,328	4,750	Service.
St. Louis, C. H.	II.	2	60	271,671	4,528	Service.
Cincinnati, O.	II.	3	22	206,300	9,170	Settling.
Cincinnati, O.	II.	1	19	136,500	6,970	Storage.
St. Louis, B. P.	III.	4	65	578,437	8,900	Settling.
St. Louis, No. 1-6	III.	6	168	1,021,087	6,080	Settling.
St. Louis, No. 7-8	III.	2	80	523,609	6,545	Settling.
St. Louis, Baden	III.	1	50	250,066	3,126	Storage.
Coshocton, O.	IV.	1	0.320	4,310	13,470	Service.

proper limits we are justified in adding considerably to the first cost of the plant. In the years 1900 and 1901 the Compton Hill service reservoir at St. Louis was cleaned under the direction of the writer. About 27,000 cu. yds. of mud were removed from one basin. Owing to the flatness and roughness of the floor and lack of proper facilities this work cost about 7.5 cts. per cu. yd.

In that same year 233,126 cu. yds. were removed from the settling basins at the Chain of Rocks reservoir for 1.017 cts. per cu. yd., or less than 1/7 of the cost at Compton Hill. This difference is partly on account of the greater inclination and smoothness of the floor of the basins and better waste-pipe connections.

The item for increased lift will depend mainly upon the cost of fuel, on the daily quantity of water and on the class of pumping engines.

The amount of water wasted in cleaning basins will depend on the effectiveness of the design, on the character and quantity of sediment, etc. In the years 1885-1888, about 12 cu. yds. of mud per million gallons supply were washed out of the St. Louis basins. Some notes by the writer show that for the new basins at the Chain of Rocks, Nos. 1-6, where no coagulant was used, about 100 gals. of water were required to wash out 1 cu. yd. of mud. This would indicate that under similar conditions 1,200 gals. per million would be wasted for cleaning basins. This would amount to about 1/10% per million gallons for pumping, which is inconsiderable.

It is a matter of interest to note the following items in regard to coagulation at St. Louis: For the year ending April, 1906, the cost of coagulating was $3.99 per million U. S. gallons, divided as follows:

Lime	$1.740
Sulphate of iron	1.532
Labor	0.622
Power	0.086
Repairs	0.010

These figures do not include pumping for coagulating plant nor fixed charges. Since that time a new coagulating plant has been built, in which modern elevating and conveying machinery with automatic controlling devices is used. It is designed to operate with a smaller force of men than the old plant. The contract price for the building with conveying machinery was $89,500. This did not include all the machinery. If we take interest, depreciation, and insurance at 10%, and assume 100,000,000 gals. per day, we would have 24.4 cts. per 1,000,000 gals. treated.

The amount of water that must be repumped for coagulating will depend upon the design of the plant. As a matter of interest we may note that in the Cincinnati plant for the year 1908, with an average of 44,000,000 gals. treated per day, about 1,000,000 gals. per day is drawn from the settling basins through the lime saturators, while 1.5 cu. ft. per min. of filtered water is used for slaking lime and 2.5 cu. ft. per min. for dissolving sulphate of iron.

The last item on our list is ground rent. It will be, of course, in some degree proportionate to the size of the plant, but will also be determined by conditions that are local.

If now we add up the estimates made for the items given, the sum will be the cost of settling proper. This cost without coagulation will not be strictly proportional to the first cost of the plant, but it seems probable that it will be nearer to that than to a value in proportion to the volume of water treated.

The best information to guide us will be the records of water-works that have used settling basins for a long time. Tables II. and III. are compiled from the records of the St. Louis Water-Works, and cover the period of use for settling of the basins at Bissell's Point. They were installed in 1871, and were used for treating the city supply for 24 years, after which and to the present time they have been used for storage of clear water. Table II. shows the expenditures each year for the last 15 years of settling, and the average daily consumption of water in million gallons.

Average Daily Consumption of Water in Millions of U. S. Gallons:

Year,	1871,	1872	1873	1874	1875	1876	1877	1878	1879	1880
Daily Av'g,	12.9	14.5	16.4	17.9	20.1	20.9	22.3	23.0	25.0	25.1

In 1882, the first repairs of magnitude after installation were made. In 1889 leaks and breaks were repaired. In 1890 joints were repointed and the coping was dressed. In Table II. the cost of coal for pumping for the last ten years is also given for comparison. The eighth column gives the cost of coal for pumping with a lift of about 50 ft. from the river to the basins. The seventh column shows the cost of pumping the clear water into the city distribution system with a lift of about 200 ft.

There were four basins, each of about 16,225,000 gals. storage capacity. They were designed for a consumption of about 30,000,000 per day with a quiet settlement of about 24 hours. They were operated on the intermittent flow, or fill and draw system. The head lost was about 14 ft. Provisions for cleaning were fairly good.

TABLE III.—COST OF SETTLING WATER, BISSELL'S POINT BASINS, ST. LOUIS, 1881-1894.

	Cost per million gallons settled.	Cost per year in per cent. of first cost.	Cost in per cent. of coal bills, low duty plant.*	Cost in per cent. of coal bills, high duty plant.†
Interest	$2.82	5.	47.5	113.
Depreciation	.79	1.4	13.4	32.0
Repairs	.054	.068	.92	2.17
Operating	.281	.34	4.72	11.25
Cleaning	.198	.23	3.35	7.90
Increased lift	.329	.585	5.6	5.6
Total	$4.472	7.623	75.49	172.01

*Figures based on actual cost of coal used.
†Cost of coal taken at 42% of the actual cost as the cost if the engines had been as economical of fuel as those now in use.

Table III. shows the cost of settling water at the old Bissell's Point basins, expressed in four different ways. The first cost of the settling basins was $578,500 and the interest was arbitrarily taken at 5%. The annual depreciation was figured in the following manner: The basins were intended to do for a consumption of 30,000,000 gals. per day, but as the average rate of using is always less than the maximum for a growing plant making extensions from time to time, a rate of 28.1 million gallons has been taken, and as for the first years of use the rate was very small, it was thought that the service was equivalent to 21 years at 28.1 million gallons per day. An annuity of $2.80 at 5% will redeem $100 in about 21 years. For salvage, 50% of the cost of the basins was taken off, as it was considered that the basins are worth for storage purposes one-half the original cost. This gives us an annual depreciation of 1.4%.

In the third column of Table III. we have each item expressed in annual cost per cent. of first cost. This disregards the quantity of water handled. The footing for this column shows 7.623%. To this we may add 0.28% for rental of land, and get 7.9% as the total annual charge. It might be well to add a small charge for accident insurance to provide for damage by earthquakes or other calamities. Therefore we might say that to run settling basins like those used at St. Louis from 1871 to 1894, would cost in round numbers about 9% per annum of the first cost.

In the fourth column of Table III. the cost is expressed in per cent. of the cost of coal used for pumping for both the river and the high-lift pumps. This is given because the cost of pumping will serve as a familiar yardstick for water-works men. The footing shows that the cost of clearing the water was about 75% of the cost of coal used for such pumping. The pumping engines used were of low efficiency. In the last column of Table III. the cost is compared with coal for pumping if engines had been used of as high efficiency as those now in use at the St. Louis water-works. The footing of this column shows that the cost of clearing the water was nearly 75% higher than the cost of coal. These values do not include any allowance for rental of land nor for accident insurance.

TABLE II.—COST OF SETTLING AT BISSELL'S POINT BASINS, ST. LOUIS, MO.

Year.	Pay-Roll Operating.	Pay-Roll Cleaning.	Pay-Roll Repairs.	Materials Repiring.	Materials Daily consumption.	Coal per million gals. High service.	Coal per million gals. Low service.	Coal per million gals. Total.
1881	$2,588.00	$1,405.48	$245.00	.....	27.5	.....	.....	.....
1882	2,400.00	2,875.00	1,259.57	.....	28	.....	.....	.....
1883	2,400.00	1,876.71	.....	.....	27.5	.....	.....	.....
1884	2,417.50	2,034.00	341.00	.....	24.8	.....	.....	.....
1885	2,400.00	3,276.00	185.56	.....	26.9	$4,885	$1,738	$6,623
1886	2,400.00	2,195.36	187.93	.....	30.5	4,600	1,889	6,489
1887	2,448.56	2,137.50	26.17	.....	30.5	4,442	1,934	6,376
1888	2,449.11	1,865.41	560.17	$157.78	32.7	4,375	2,345	6,720
1889	3,991.25	2,927.35	908.30	129.83	32.3	3,850	1,904	5,754
1890	4,020.00	1,386.00	1,139.63	334.88	35.2	3,462	1,763	5,225
1891	4,020.00	1,411.20	1,233.56	408.69	38.6	3,298	1,587	4,885
1892	4,028.00	2,286.26	36.67	397.16	42.1	3,484	1,830	5,314
1893	4,319.97	2,810.89	170.55	629.74	47.5	3,805	1,969	5,774
1894	4,617.99	3,519.19	171.95	809.10	52.9	3,779	2,041	5,820
1895	4,588.26	2,688.20	.....	.....	....	.....	.....	.....
Total	$49,088.64	$34,694.55	$6,466.66	$2,927.18	477.0			
Average						$3.998	$1,900	$5,898

A Comparison of the Various Processes of Preserving Timber.

By G. B. SHIPLEY*.

Wood is an organic body, with an outer layer composed of sapwood and water, containing cells in which there is a large amount of organic substances and with an inner structure called heartwood, usually distinguished from the sapwood by its dark red color. Heartwood is filled with gums and resins and contains less water than sapwood; therefore, it is more durable.

The organic substance is subject to being destroyed by either bacteria, insects, fungi or spores, which require food and entering the minute cells, destroy the cell walls (cellulose); furthermore, the fungus requires heat, air and moisture. Decay can therefore be prevented by excluding heat, air or moisture, and as it is not practical to do this, the cell walls or fibers must be impregnated with an antiseptic that will prevent the formation of bacteria, insects, fungi or spores. To increase the mechanical life of timber used as ties it is also necessary to provide proper rail fastenings and plates so that the constant hammer and vibration is distributed and absorbed by the entire tie and thus avoid fractures on small portions.

To realize the importance of timber preserving it is necessary to appreciate the millions of ties that are used each year by the railroads and compare the first cost of laying in a track where untreated ties are used with a track where treated ties are used. By assuming that the capital invested in the ties should earn 4% compound interest and that the average untreated tie will have a life of five years in the roadbed and the treated tie 12 to 15 years, the first cost would represent an investment which must be extended over the period of their usefulness and wiping out, each year, a fixed charge for depreciation, the following figures will be obtained:

First Cost:	Untreated.	Treated.
Cost of tie delivered	$0.50	$0.50
Cost of laying in track	.15	.15
Cost of creosoting	....	.35
Total cost in roadbed	$0.65	$1.00

Assuming that tie will last five years in roadbed when untreated and 15 years if treated we have the following result:

	Untreated.	Treated.
First cost	$0.65	$1.00
4% compound interest for 5 years	.14	...
4% compound interest for 15 years	...	.80
Total cost for useful life of the tie	$0.79	$1.80
Annual Depreciation:		
Based on 5 years of life	$0.58	....
Based on 15 years of life	...	.12
Comparison of Saving:		
Depreciation per year on each untreated tie		$0.158
Depreciation per year on each treated tie		.120
Difference on each tie		.038

This is equal to a saving of $0.038 per year on each tie and demonstrates that the untreated tie costs about 31% more to maintain than the treated tie, or represents a saving of nearly $100.44 for each mile of track containing 2,880 ties.

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The average size timber treating plant will treat about one million ties per year, and will represent a saving of $38,000 per year.

Modern timber preserving is accomplished by impregnating the wood fibers or cell walls with antiseptics that prevent decay, such as is found in coal tar, creosote oil and metallic salts of zinc chloride.

Zinc chloride is a metallic salt, containing little free acid, not more than a trace of iron and about 94% of soluble chloride of zinc. It is placed on the market in drums holding 1,000 lbs. each of concentrated zinc chloride, or as a 52% solution in tank cars.

Creosote is a dead oil of coal tar and that portion of the coal tar which distills between 200° and 355° Centigrade, and which is sometimes mixed with residual oils from the manufacture of crude carbolic acid, naptholene and anthracene, the specific gravity ranging from 1.011 to 1.1.

Zinc chloride is manufactured in the United States, but there is not sufficient creosote oil manufactured here to supply the demand and consequently it is necessary to secure the additional supply from Europe. The foreign creosote oil is delivered in tank steamers in quantities of from 750,000 to 1,000,000 gals., at a temperature ranging between 100° to 120° F.

The primary stage in any timber preserving process consists of seasoning the wood by piling in the open air or steaming in closed retorts to expel the moisture and sap. Climatic conditions and altitude govern air seasoning, for instance in warm, dry climates it will only require three to six months, whereas in cold, damp climates

FIG. 1. VIEW OF STORAGE YARD OF PENNSYLVANIA R. R. TIMBER PRESERVING PLANT, MT. UNION, PA.

six to twelve months. Steaming ties requires from two to four hours; steaming timber four to eight hours, depending on structure of material.

The time required to treat any wood depends upon the structure of the wood, size of wood, shape of wood, seasoning, method of treating, preservative used and the residual preservative left in the wood after treatment.

Treating Processes.

The following methods of treating timbers are receiving the most consideration:

1. Burnettizing process.
2. Wellhouse process.
3. Absorption process.
4. Full cell creosote process.
5. Rueping process.
6. Lowry process.
7. Card process.

These processes, with the exception of the Absorption Process, are manipulated by mechanical contrivances such as pressure pumps, vacuum pumps and air compressors, and can be controlled to suit the wood structure, while with the Absorption Process the treatment is governed by temperature and atmospheric pressure, therefore is limited to certain woods.

TEMPERATURES WHILE TREATING.—The average temperatures while testing are as follows:

Light creosote oil	170° F.
Heavy creosote oil	180° F.
Zinc chloride solution	140° F.

Burnettizing Process.

This is often referred to as the Zinc Chloride Process and consists of impregnating the wood fibers with a solution containing ½-lb. of dry zinc per cu. ft. of wood and is operated as follows:

The wood is first air seasoned in the open, or steamed in retorts to expel the moisture, then a vacuum is produced and maintained until solution is introduced and wood is completely submerged, the pressure is then increased to about 100 lbs. or 125 lbs. per sq. in., by pumping in additional solution until required penetration and impregnation is obtained, when solution is drained from retort.

Timber treated with ½-lb of dry zinc chloride per cu. ft. will contain 41.67 lbs. of dry zinc chloride or 2,430 lbs. of solution per 1,000 ft. of lumber, making the total weight of lumber about 5,763 lbs. per 1,000 board ft.

TIME REQUIRED.

	Hrs.	Min.
Steaming to 20 lbs. pressure	0	30
Steaming 20 lbs. to 35 lbs. pressure	3	30
Blowing off steam	0	15
Vacuum	0	45
Solution to about 100 lbs. pressure	0	45
Solution maintained to 100 lbs. pressure	1	15
Forcing back solution	0	15
Total cycle	7	15
If steaming time is reduced 2 hrs. then total cycle	5	15

Wellhouse Process.

This is often referred to as the Zinc Tannin Process and consists of impregnating the wood fibers with a hot solution containing about one-half pound of dry zinc chloride plus ½% of glue or gelatine per cu. ft. of wood, then following by injecting a second solution containing ½% of tannic acid. The purpose of the tannin is to solidify the first injection to prevent leaching and is operated as follows:

The wood is first air seasoned in the open or steamed in retorts to expel the moisture, then a vacuum is produced and maintained until solution is introduced and wood is completely submerged, the pressure is then increased about 100 to 125 lbs. per sq. in. by pumping in additional solution until required penetration and impregnation is obtained, when solution is drained from retort and the second movement takes place by filling the retort with solution containing tannic acid and increasing the pressure by pumping additional solution at about 100 or 125 lbs. per sq. in. until required penetration is obtained, when solution is drained from retort.

APPROXIMATE TIME REQUIRED.

	Maximum time. Hrs.	Min.
Steaming to 20 lbs. pressure	0	30
Steaming 20 to 35 lbs. pressure	3	30
Blowing off steam	0	15
Vacuum	0	45
Solution and glue to 100 lbs. pressure	0	45
Solution and glue maintained at 100 lbs. pressure	1	15
Forcing back solution and glue	0	15
Tannin introduced to 100 lbs. pressure	0	20
Tannin maintained at 100 lbs. pressure	0	50
Forcing back tannin	0	15
Total cycle	8	40
If steaming time is reduced 2 hrs. then total cycle equals	6	40

Absorption Process.

This is often referred to as the Non-pressure Process and consists of submerging the wood in a boiling preservative at a temperature of from 180° to 230° F., then following with a cold preservative as follows:

The wood is first air seasoned in the open to reduce the moisture, then placed in either an open or closed receptacle where it is submerged in a hot preservative which expels the air and additional moisture, the receptacle is then drained and the wood submerged in a cold preservative. The first movement opens the pores or cells of the wood forming a vacuum within, while the second movement causes absorption due to the difference in temperature and atmospheric pressure. This process can be used in either open tanks or closed retorts. For treating the butts of poles, fence posts, piling and small quantities of ties the open tank is satisfactory, but for treating large quantities of material the closed retort is recommended where thorough impregnation is desired.

The time of treatment is as follows:

TIME REQUIRED.

Green Timber:	
Boiling hot preservative from 8 to 10 hours.	
Bath in cold preservative from 8 to 16 hrs.	
Total time of treatment, 16 to 26 hrs.	
Seasoned Timber:	
Boiling in hot preservative from 3 to 6 hrs.	
Bath of cold preservative from 4 to 8 hrs.	
Total time of treatment, 7 to 14 hrs.	

With this process it is possible to impregnate a limited class of woods with about 6 to 12 lbs. of creosote oil per cu. ft.

Full Cell Creosote Process.

This consists of impregnating the wood fibers and cells of ties with 6 to 12 lbs. of creosote oil per cu. ft. and timber and piling with 10 lbs. to 20 lbs. of creosote oil per cu. ft., as follows:

The wood is first seasoned in the open or steamed in the retorts (generally both) to reduce the moisture and expel sap, then a vacuum is produced and maintained until creosote oil is introduced and wood is completely submerged. The pressure is then increased to from 100 to 125 lbs. per sq. in. and maintained until the desired penetration and impregnation is secured, when creosote oil is drained from tanks. In some cases a vacuum is produced and maintained at the finish to drain the surplus oil from the exterior of wood to prevent loss by drippage after wood has been removed from retorts.

APPROXIMATE TIME REQUIRED.

10-lb. Treatment.	Hrs.	Min.
Steaming to 20 lbs. pressure	0	30
Steaming 20 to 35 lbs. pressure	3	30
Blowing off steam	0	15
Vacuum	0	45
Creosote to 100 lbs. pressure	1	30
Forcing back solution	0	15
Vacuum	0	30
Total cycle	7	15
If steaming time is reduced 2 hrs. then total cycle equals	5	15

Rueping Process.

This is often referred to as a partial cell treatment and it is used principally in connection with creosote oil. It consists of forcing compressed air into the pores or cells of the wood, then at a higher pressure forcing in creosote oil without relieving the air pressure. Upon relieving the combined pressure the air expands and forces out surplus oil, leaving the wood fibers impregnated.

The wood is first air seasoned in the open or steamed in the retorts (sometimes both) to reduce the moisture, then a vacuum is produced and next the air is compressed to from 80 to 100 lbs. per sq. in.; thus filling all the wood cells with compressed air and by air equalizing reservoirs or pumps the retorts are filled with oil without releasing the air pressure. The oil pressure is thus started at from 80 to 100 lbs. per sq. in. and gradually increased to about 100 or 150 lbs. per sq. in., having the effect of compressing the air in the cells to a smaller volume and permitting about 10 to 12 lbs. of creosote per cu. ft. to enter. The pressure is then released and oil drained from retorts, then a vacuum is produced, which causes the air within the cells to expand and forces the surplus oil out of the wood, leaving the wood fibers impreg-

WEIGHT OF CREOSOTED TIMBER.

Lbs. of creosote in each ft. of timber	6	8	10	12	14	16	18	20
Lbs. creosote in 1,000 ft. B. M.	500	667	834	1,000	1,167	1,333	1,500	1,667
Weight of 1,000 ft. treated timber	3,833	4,000	4,167	4,333	4,500	4,666	4,833	5,000

nated with from 4 to 6 lbs. of creosote per cu. ft. This process is best adapted for treatment of ties.

APPROXIMATE TIME REQUIRED USING EQUALIZING CYLINDERS.

	Hrs.	Min.
Air to 80 lbs. pressure	0	30
Transferring oil	0	20
Creosote to 150 lbs. pressure	1	30
Maintaining 150 lbs. pressure	0	15
Forcing back oil	0	20
Vacuum	1	00
Maintaining vacuum	0	15
Draining	0	10
Total cycle	4	20

This time is based on thoroughly air seasoned ties.

Lowry Process.

This is often referred to as a partial cell treatment and it is used in connection with creosote oil. It consists of forcing creosote oil into the wood cells and then drawing out by vacuum the surplus oil, leaving only the wood fibers impregnated.

The wood is first air seasoned in the open, then placed in retorts and submerged in creosote. The pressure is then applied by forcing in additional creosote of 10 to 12 lbs. per cu. ft. at about 180 lbs. pressure so as to saturate the pores and the surplus emulsion from the exterior of the wood to prevent loss by drippage when wood is removed from retort.

It is necessary to keep the emulsion constantly agitated to prevent a separation of the zinc and creosote and to accomplish this a centrifugal pump draws the emulsion from top of retorts and discharges into the bottom through a perforated pipe.

This process is used principally in the treatment of ties.

	Hrs.	Min.
Steaming to 20 lbs. pressure	0	30
Steaming 20 to 35 lbs. pressure	3	30
Blowing off steam	0	10
Vacuum	1	00
Emulsion to 120 lbs. pressure	1	00
Maintaining 120 lbs. pressure	1	30
Forcing back oil	0	15
Vacuum	0	20
Draining	0	10
Total cycle about	8	25
If steam time is reduced 2 hrs. then cycle equals	6	25

Selection of Process.

There is a great diversity of opinion among engineers and operators as to what is the best process or preservative to use. However, it is reasonable to assume that the foregoing are receiving the most favorable consideration by the leading railroads throughout the world and especially in our own country.

The question of treatment is resolved to a matter of investment and to secure the best results, the wood must be treated so that the chemical life will be equivalent to the mechanical life. Therefore, in considering this vital problem, the mechanical arrangements should be just as important as the treatment. In many instances the initial cost of treatment has been the important factor and the cost of treatment will assume the following rotation:

1. Burnettizing Process.
2. Wellhouse Process.
3. Card Process.
4. Rueping and Lowry Processes.
5. Absorption Process.
6. Full Cell Process.

The full cell creosote process is the most expensive first cost, and is probably considered the very best for all conditions. It is particularly adapted for treatment of piling and timber, whereas the others are being used the most extensively in the treatment of ties.

The Absorption Process is advocated by some engineers as a very cheap installation and satisfactory treatment for general work and where small quantities are to be treated and time is of no consequence, but to date it is not a thorough success for plants that handle large quantities and where absolute control of treatment is desired. To secure uniform impregnation, it is obviously necessary to use mechanical apparatus.

From modern practice it is evident that the partial treatment for ties and full cell treatment for piling and timber is the most favorable among consumers.

Mechanical Equipment.

The equipment required for a timber treating plant will depend entirely on the process and wood to be treated, but will generally be composed of the following:

1. Boilers for supplying steam to machines, heating coils and steaming timber.
2. Vacuum pumps for withdrawing the moisture, sap and surplus preservative.
3. General service pumps for transferring the preservatives from tanks to retorts.
4. Pressure pumps for injecting the preservative into the wood cells.
5. Air compressors for blowing back the oil from retorts to tanks and, in the Rueping Process, for manipulating the first operation.
6. Fire pumps for protecting the timber in yards and buildings.
7. Feed pumps for supplying boilers.
8. Heaters for heating boiler feed water.
9. Engine and generator unit for electric lights and supplying current to operate electric yard locomotives.
10. Steel and wood tanks for storage of preservatives and water.
11. Tie and bolster cars for the transferring of timber to and from retorts.
12. Transfer cars for cylinder entrance.
13. Hoisting engines for handling cars in yards.
14. Electric locomotives for handling cars in yards.
15. Overhead equalizing reservoirs for transferring oil. (In the Rueping process.)
16. Underground reservoirs for quick discharge of retorts.
17. Piping and fittings.
18. Steel buildings.

RETORTS.—The retort is a horizontal cylinder arranged with a closed head on one end and a door on the other, or doors on both ends. The inside of retort is fitted with rails to permit filling with ties, timber or piling on portable cars, and the rails are so arranged that steam coils having the maximum heating surface can be placed between. The object of steam coils is to maintain a high temperature of the preservative.

The retorts are supported on stationary and expansion saddles, which can be arranged for either timber or concrete foundations.

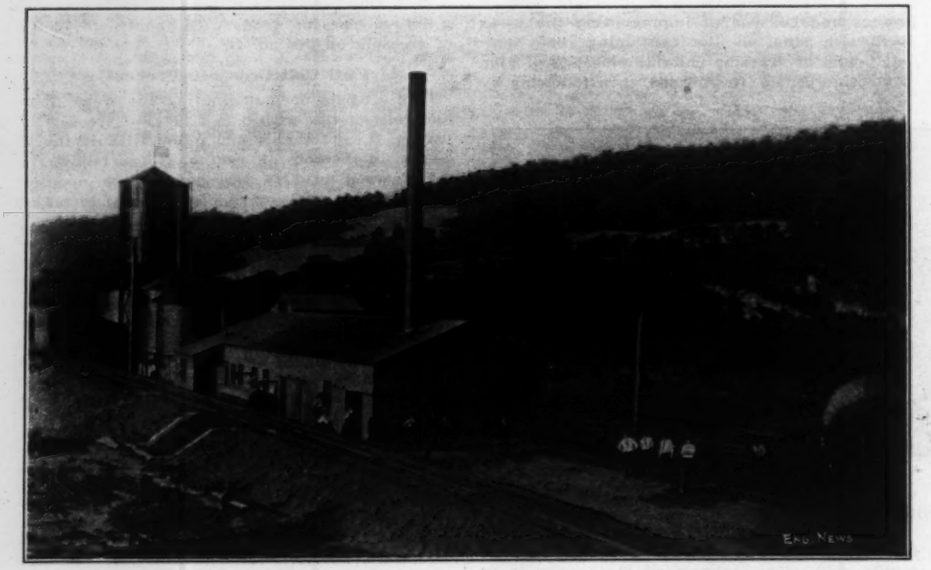


FIG. 2. TIMBER PRESERVING PLANT OF PENNSYLVANIA R. R., MT. UNION, PA., SHOWING LOCOMOTIVE AND CHARGE OF CARS COMING FROM RETORT.

cells, after which the retort is drained and a quick vacuum is produced and maintained from 1½ to 2 hours, leaving the wood fibers impregnated with from 4 to 6 lbs. of creosote per cu. ft. This process is used principally in the treatment of ties.

APPROXIMATE TIME REQUIRED.

Ties thoroughly seasoned:

	Hrs.	Min.
Creosote to 180 lbs. pressure	2	00
Draining oil from retort	0	10
Vacuum	2	00
Draining	0	10
Total cycles about	4	20

Card Process.

This process consists of impregnating the wood cells with an emulsion consisting of zinc chloride and creosote oil.

The wood is first air seasoned in the open or steamed in the retorts (generally both) to reduce the moisture and expel the sap. Then a vacuum is produced and maintained for one hour, when retort is filled with the hot emulsion consisting of ⅛-lb. of dry zinc and from 1½ to 4 lbs. of creosote per cu. ft. The pressure is then applied by forcing in additional emulsion at about 100 to 150 lbs. pressure per sq. in., after which the retort is drained and a vacuum produced and maintained for about 30 minutes to draw

ZINC CHLORIDE TREATMENT WEIGHTS.

One-half pound of zinc chloride per cu. ft. Zinc chloride solution at 8.46 lbs. per gal. Specific gravity, 1.015. Absorption about 45%.

Kind of Tie.	Hewn Tie.			
Size of Tie.	6 × 8 in. × 8 ft.	6 × 8 in. × 8 ft. 6 in.	7 × 9 in. × 8 ft.	7 × 9 in. × 8 ft. 6 in.
Cu. ft. in each tie	2.62	2.78	3.45	3.66
Weight of Green tie in lbs.	137	145	180	191
Weight of Seasoned tie in lbs.	105	112	138	141
Weight of dry zinc per tie in lbs.	1.31	1.39	1.72	1.83
Weight of solution per tie in lbs.	76.50	81.00	101.00	107.00
Total weight treated tie in lbs.	181.50	193.00	239.00	228.00
	Sawed Ties.			
Cu. ft. in each tie	2.67	2.83	3.50	3.72
Weight of Green tie in lbs.	139	141	182	194
Weight of Seasoned tie in lbs.	107	114	140	170
Weight of dry zinc per tie in lbs.	1.34	1.43	1.75	1.86
Weight of solution per tie in lbs.	77.80	82.50	102.00	103.00
Total weight treated tie in lbs.	184.80	196.50	242.00	279.00

The commercial sizes of retorts are as follows:

72 in. dia. × 40 ft.	74 in. dia. × 132 ft.
72 in. dia. × 50 ft.	84 in. dia. × 108 ft.
72 in. dia. × 108 ft.	84 in. dia. × 132 ft.
72 in. dia. × 132 ft.	108 in. dia. × 132 ft.
74 in. dia. × 52 ft.	108 in. dia. × 150 ft.
74 in. dia. × 108 ft.	

The retort shells are made of the very best open hearth flange steel of thicknesses ranging from ⅜-in. to 1 in., depending on diameters, working pressure and preservative used. With some preservatives the chemicals cause rapid deterioration of the plates, while other preservatives have no effect on the plates.

RETORT DOORS.—The most important detail in connection with a plant are the retort doors, the construction of which depends on the working pressure. There are four standard types, as follows:

A plain bolted door with slotted holes and using ordinary tee head bolts, for low pressures.

A spider door with center screw and lever nut arranged so that each lever has independent connection to frame, for low pressure.

A spider door with center screw and lever nut, arranged so that the levers are connected to frame by a continuous flange ring, for high pressures.

A solid cast steel bolted door with slotted holes using tee head swing bolts, for high pressure.

All types of doors are made with a projecting circular spigot which matches a circular groove in the frame and the joint is formed by inserting a gasket in the groove, which is usually made of asbestos rope thoroughly dipped and painted with a mixture of graphite and oil.

It is a matter of opinion among operators as to which type of door is the best. Where time is an important factor the spider door is possibly the best, for it can be opened or closed in about 2½ min., whereas the other bolted doors required about 5 min. The bolted doors have less parts, therefore cost less to maintain than spider doors.

TRAM CARS.—A very important detail in connection with any timber treating plant is the cars for transferring the timber to and from the retorts and storage yards.

The two types of cars used for this purpose are the "tie car," for carrying ties, and the "bolster car," for carrying timber, piling, poles, etc.

Piling.

Piling will range from 8 to 20-in. diameter and from 10 to 90 ft. long. Average sizes running about as follows:

10 in. dia. to 14 in. dia. by 28 ft. long.
11 in. dia. to 15 in. dia. by 40 ft. long.
8 in. dia. to 18 in. dia. by 60 ft. long.
8 in. dia. to 20 in. dia. by 90 ft. long.

The average treatment of piling is from 10 lbs. to 20 lbs. of creosote per cu. ft.

Green piling will weigh about 55 lbs. per cu. ft.

Seasoned or steamed piling will weigh about 40 lbs. per cu. ft.

The actual cost of treating piling will be about $0.10 per cu. ft. for a 10-lb. treatment, and for each additional pound add one cent per cu. ft., all depending on treatment and structure of wood.

Shipment of Treated Wood.

Creosoted ties and timber are shipped in cattle cars, gravel cars or flat cars, and never in box cars, as the creosote odor is detrimental to provisions.

A 32-ft. cattle car will hold about 300 ties.
A 42-ft. cattle car will hold about 400 ties.
A gravel car will hold about 280 ties.
A flat car will hold about 170 ties.

Estimated Cost of Treatment.

The spacing of ties is governed by the traffic, but for estimating purposes allow about 2,880 of 7 × 9-in. × 8-ft. and 3,168 of 6 × 8-in. × 8-ft. ties for each mile of track.

APPROXIMATE COST OF TREATING TIES, EXCLUDING ROYALTY.—Average size tie 7 × 9 in. × 8 ft. equals 3.45 cu. ft.

"B"—Burnettizing, about ½-lb dry zinc per cu. ft. $0.12 per tie.

"C"—Wellhouse, about ½-lb. zinc per cu. ft. plus glue and tannin, $0.16 per tie.

"D"—Card, about 1½ lbs. creosote and ½-lb. dry zinc per cu. ft., $0.18 per tie.

"E"—Rueping, about 6 lbs. creosote per cu. ft., $0.225 per tie.

"F"—Lowry, about 6 lbs. creosote per cu. ft., $0.225 per tie.

"G"—Absorption, about 6 lbs. creosote per cu. ft., $0.23 per tie.

"H"—Full cell, about 10 lbs. creosote per cu ft., $0.335 per tie.

Above costs are based on creosote oil at $0.07 per gal. and dry zinc chloride at $0.04 per lb.

It costs about 1½-ct. per tie to handle in the yard.

TIMBER.—The cost of creosoting timber with 10 lbs. of creosote per cu. ft. will be about $8 per 1,000 ft. B. M., and for each additional pound of creosote used add about $0.75 per 1,000 ft. B. M. based on creosote oil at $0.07 per gal.

The cost of Burnettizing timber with ½-lb of dry zinc chloride per cu. ft. will be about $4 per 1,000 ft. B. M. board feet.

PLANT ARRANGEMENTS.—The general arrangement of plants will depend on the following conditions:

TABLE I.—SHOWING CAPACITY OF TIMBER PRESERVING PLANTS.

Plant No.	Size of Plants. No. of Cylinders.	Cylinders Dia. ins.	Cylinders Length. ft.	Capacity Per Year of 300 Days — Treating Processes — 3 Charges to Each Retort Per Day of 24 Hours. Burnettizing—Wellhouse, Card and Full Cell. No. of Ties	Cu. Ft.	Thousand Ft. of Lumber.	4 Charges to Each Retort Per Day of 24 Hours. Rueping & Lowry. No. of Ties.	Cu. Ft.	Thousand Ft. of Lumber.
1	1	74	42	171,000	598,500	7,182	228,000	798,000	9,576
2	1	74	50	205,200	718,200	8,618.4	273,600	957,600	1,491.2
3	1	74	108	273,600	957,600	11,491.2	346,800	1,213,000	14,556
4	1	74	132	540,000	1,890,000	22,680	720,000	2,520,000	30,240
5	2	74	132	1,080,000	3,780,000	45,360	1,440,000	5,040,000	60,480
6	3	74	132	1,620,000	5,670,000	68,040	2,160,000	7,560,000	90,720
7	4	74	132	2,160,000	7,560,000	90,720	2,880,000	10,080,000	120,960
8	5	74	132	2,700,000	9,450,000	113,400	3,600,000	12,600,000	151,200
9	6	74	132	3,240,000	10,340,000	124,080	4,320,000	15,120,000	181,440
10	1	84	108	585,000	2,047,500	24,570	780,000	2,730,000	32,760
11	1	84	132	720,000	2,520,000	30,240	960,000	3,360,000	40,320
12	2	84	132	1,440,000	5,040,000	60,480	1,920,000	6,720,000	80,640
13	3	84	132	2,160,000	7,560,000	90,720	2,880,000	10,080,000	120,960
14	4	84	132	2,880,000	10,080,000	120,960	3,840,000	13,440,000	161,280

TABLE II.—SHOWING APPROXIMATE COSTS OF COMPLETE TIMBER PRESERVING PLANTS.

Plant number	1		2		3		4		5		6		7	
Acres required for complete plant and yard	7		8		10		20		39		59		78	
Total ties	170,000		205,000		260,000		540,000		1,080,000		1,620,000		2,160,000	
Storage: Equivalent in 1,000 board ft. of lumber	7,040		8,490		10,770		22,400		45,000		67,000		90,000	
Capacity:														
Creosote in gallons	110,000		133,000		168,000		350,000		700,000		1,000,000		1,400,000	
Water in gallons	7,200		8,500		11,000		22,500		45,000		67,500		90,000	
Total miles of track in yard	1.00		1.23		1.23		2.8		5.6		7.7		9.8	
Length of loading platform	126 ft.		150 ft.		325 ft.		400 ft.		400 ft.		530 ft.		660 ft.	
Particulars of costs	Wgt. in tons.	Cost.	Wgt. in tons.	Cost.	Wgt. in tons.	Cost.	Wgt. In tons.	Cost.	Wgt. In tons.	Cost.	Wgt. In tons.	Cost.	Wgt. in tons.	Cost.
Machinery	61.00	$10,600	70.00	$13,200	131.00	$21,200	163.00	$25,700	278.00	$42,000	363.00	$54,400	458.00	$66,900
Creosote tanks	24.30	1,900	29.00	2,260	36.50	2,850	45.00	3,900	90.00	6,950	123.00	9,500	205.00	16,000
Water tanks	3.00	360	3.70	440	4.80	570	9.70	1,160	17.50	2,100	27.00	3,260	35.00	4,200
Tram cars	25.00	1,980	28.30	2,340	61.00	4,860	75.00	6,000	148.00	11,820	220.00	17,580	293.00	23,400
Fire service	11.50	800	13.60	950	17.20	1,200	35.80	2,500	71.60	5,000	105.00	7,300	140.00	9,800
Yard hoists	3.60	600	4.00	700	7.50	1,200	9.00	1,500	18.00	3,000	20.00	3,200	22.00	3,400
Steel buildings	15.00	1,600	17.80	1,900	27.20	2,900	30.00	3,200	37.40	4,000	67.50	7,200	84.00	9,000
Excavating and Foundations	....	1,150	....	1,350	....	2,000	....	2,250	....	2,800	....	5,000	....	6,300
Loading platform	....	650	....	750	....	1,625	....	2,000	....	2,750	....	3,640	....	4,500
Tracks	105.00	5,400	130.00	6,600	130.00	6,600	294.00	14,900	590.00	29,800	810.00	41,000	1,040.00	52,600
Land	....	700	....	800	....	1,000	....	2,000	....	3,900	....	5,900	....	7,800
Total	248.40	$25,720	296.40	$31,290	415.20	$46,005	661.50	$65,110	1,250.50	$114,120	1,735.70	$157,980	2,277.00	$203,900

Plant number	8		9		10		11		12		13		14	
Acres required for complete plant and yard	98		117		21		26		47		78		104	
Total ties	2,700,000		3,240,000		585,000		720,000		1,290,000		2,160,000		2,880,000	
Storage: Equivalent in 1,000 board ft. of lumber	112,000		134,000		24,200		30,000		53,500		90,000		118,000	
Capacity:														
Creosote in gallons	1,700,000		2,000,000		380,000		500,000		1,000,000		1,500,000		2,000,000	
Water in gallons	110,000		135,000		25,000		30,000		60,000		90,000		120,000	
Total miles of track in yard	12.5		14.2		2.84		3.5		6.1		10.00		12.8	
Length of loading platform	660 ft.		800 ft.		325 ft.		400 ft.		400 ft.		530 ft.		700 ft.	
Particulars of costs	Wgt. in tons.	Cost.	Wgt. in tons.	Cost.	Wgt. In tons.	Cost.	Wgt. In tons.	Cost.	Wgt. In tons.	Cost.	Wgt. In tons.	Cost.	Wgt. in tons.	Cost.
Machinery	544.00	$79,400	634.00	$85,900	185.00	$28,900	225.00	$34,700	384.00	$57,800	507.00	$89,200	656.00	$109,800
Creosote tanks	225.00	17,600	243.00	19,000	52.50	4,100	61.50	4,750	123.00	9,500	184.50	14,250	240.00	19,000
Water tanks	44.00	5,230	53.00	6,300	10.80	1,290	13.00	1,550	24.00	2,870	35.00	4,200	48.00	5,740
Tram cars	365.00	29,160	440.10	35,040	66.00	4,290	82.00	6,500	160.00	12,805	240.00	19,045	319.00	25,350
Fire service	177.00	12,400	208.00	14,500	37.00	2,600	47.00	3,250	83.00	5,800	1,400.00	9,750	1,860.00	13,000
Yard hoists	24.00	3,600	26.00	3,800	10.00	1,600	12.00	2,000	24.00	4,000	25.00	4,200	26.00	4,400
Steel buildings	101.00	10,800	114.00	12,000	32.70	3,500	41.00	4,400	59.00	6,300	801.00	8,600	1,000.00	10,700
Excavating and Foundations	....	7,600	....	8,400	....	2,450	....	3,100	....	4,400	....	6,000	....	7,500
Loading platform	....	4,950	....	6,000	....	1,625	....	2,000	....	3,000	....	4,500	....	5,600
Tracks	1,310.00	63,000	1,500.00	74,500	300.000	15,200	370.00	18,700	640.00	$32,200	1,070.00	53,600	1,500.00	73,800
Land	....	9,800	....	11,700	....	2,100	....	2,600	....	4,700	....	7,800	....	10,400
Total	2,790.00	$243,540	3,218.00	$277,140	694.00	$67,655	851.50	$83,550	1,497.00	$143,375	4,252.50	$221,145	5,655.00	$285,290

Tie storage is based on 75% of the yearly capacity of plant, or 9 months' seasoning.
Creosote oil storage is equal to 60 days' supply when running.
Track is based on 60 lbs. per yd. rail. Steel at $30 per ton, ties at 50c. each and laying track at 10c. per ft.
Retorts are designed for working pressure of 250 lbs. per sq. in.
Plants are arranged for either burnettizing, wellhouse, absorption, full cell, Rueping, Lowry or card process.
Hoists are for transfering tram, if electrical locomotives are to be used, add or deduct in accordance.
Where plants are treating piling and timber it is necessary to have a traveling yard crane, which will cost about $5,000 to $7,000, depending on capacity.

1. Amount of ties, lumber, piling, etc., to be treated per year.
2. Nature of wood to be treated.
3. Time required to season the wood.
4. Location for receiving and distribution of material.
5. Drainage of yards.
6. Construction of buildings.
7. Fresh water supply.
8. Process to be used.
9. Working pressure for retorts.

The storage of ties or lumber will depend on arrangement of plant and method of piling the timber or ties. The best yards are layed out so that the length is about four to five times the width and the tracks from 50 ft. to 65 ft. c. to c. A very convenient form of piling the ties is to lay two ties on the ground to act as sills, then place crosswise on top seven ties, equal distance apart, and continue upward to a height of 22 ties. This arrangement permits of a good air circulation and is convenient for handling.

When estimating on total yardage required for buildings, loading platform, tracks, etc., it is safe to allow 1.57 sq. ft. of land for each tie.

Capacity and Costs of Plants.

Tables I.-II. give the capacities and costs of plants that are designed for modern practice, and as it is not possible to give exact costs on account of the complex conditions, the reader will realize the value of these tables for estimating the costs of proposed propositions.

Modern Plants.

Two very interesting plants have recently been constructed by the Pennsylvania R. R. Co.; one at Mount Union and the other at Greenwich Point, Philadelphia, Pa. Although these plants have been in operation a short time, they have proved successful.

The Mount Union plant, shown on photographs, will have a capacity of about 500,000 ties per year, and consists of one retort 74 ins. in diameter by 132 ft. long, designed for working pressure of 250 lbs. per sq. in., with the necessary auxiliaries, such as air compressor, vacuum pump, oil pressure pump, general service pump, boiler feed pump, Card circulating pump, boilers, heaters, electric lighting set, wooden tank for zinc chloride, steel tank for storage of creosotes, steel tank for water storage and complete equipment of tie and bolster cars. This plant is designed for treating principally mixed oaks with modern processes, using either creosote oils or zinc chloride as the antiseptic.

The buildings are of steel construction throughout and the storage yard is well equipped with a fire system.

The plant at Greenwich Point, Philadelphia, consists of one cylinder 74 ins. in diameter by 40 ft. long, together with air compressor, general service pump, boiler, and vertical tanks. This is essentially a non-pressure plant and is arranged for securing the necessary impregnation by absorption due to the difference in temperature of the oils and atmospheric pressure.

At present time the creosote oils are being secured from Germany through the importers, C. Lembcke & Co. The oil is transported in tank steamer holding about one million gallons and is transferred at the docks into two 500,000-gal. storage tanks, there to be distributed in tank cars over the system.

These plans were designed and installed under the direction of Mr. E. A. Sterling, Forester of the Pennsylvania R. R., and Mr. G. B. Shipley. The Allis-Chalmers Co., of Milwaukee, furnished the complete detail machinery designs and all machinery erected on foundations.

A SPEED RECORD FOR AMERICAN WARSHIPS was made by the United States torpedo boat destroyer "Reid" on Oct. 6, 1909, when this vessel on a trial trip made her fastest mile over a measured course at a 34.548 knot speed, nearly a knot better than the record made by her sister ship the "Flusser." The mean of the top speed runs of the "Reid" on this standardization trip was 33.75 knots, and a shaft-horsepower of 15,000 was developed. These two destroyers, twin ships built by the Bath Iron Works, of Bath, Me., are 294 ft. long, 26 ft. beam and 8-ft. draft. They each have a tonnage of 902 and are driven by triple screws, connected to Parson's turbines.

City Planning in Pittsburg.

The Pittsburg Civic Commission, a body of 16 men, all prominent, in representative responsible positions and serving voluntarily, appointed by Mayor Guthrie, is generally regarded as the outcome of the so-called Pittsburg Survey, which was, in brief, a broad study of the people, their city and their work, under grants of funds from the Russell Sage Foundation for the Improvement of Living Conditions.* The Commission has even been styled a "permanent survey" with its various committees on public health, housing, transportation, industrial accidents, education, courts, charities and civic plans.

The President is Mr. H. D. W. English, former President of the Chamber of Commerce, with three Vice-Presidents, Mr. D. P. Black, President of the Real Estate Trust Co., Mr. J. W. Beatty, Director of Fine Arts of the Carnegie Institution, and Mr. H. J. Heinz, President of the H. J. Heinz Co., food packers.

Among the Commissioners and Chairman of the Public Health Committee the engineering profession will recognize Mr. Maurice Knowles, M. Am. Soc. C. E., Chief Engineer of the Pittsburg Bureau of Filtration. The routine work of the Commission is in the hands of Mr. Allen T. Burns, General Secretary, and Mr. J. J. Donnell, Treasurer. The work is supported by contributions.

The Commission has associated with it an Advisory Board, whose personnel includes such well-known men as R. W. De Forest, Paul V. Kellogg and Seth Low of New York City, Mr. Joseph A. Holmes, of the U. S. Geological Survey, Washington, Mr. C. J. Bonaparte, of Baltimore. Mr. G. W. Guthrie, Mayor of Pittsburg, is Chairman of the Advisory Board, with Judge Joseph Buffington, U. S. Circuit Court, as Vice-Chairman.

The Commission is at present turning its attention, amongst other things, to city planning, with the view of making it possible for the community to control the physical development of the industrial district, making that growth satisfactory and economical. Mr. Bion J. Arnold, M. Am. Inst. E. E., of Chicago, Mr. John R. Freeman, M. Am. Soc. C. E., of Providence, R. I., and Mr. Frederick L. Olmstead, of Brookline, Mass., have recently been retained in an advisory capacity for this work. These men will not pass judgment on any single specific proposed improvement, but at first will advise the Commission, as their professional experience allows, as to how the general problem may best be approached. The following summary of the lines of investigation to be scrutinized by the Advisory Board is taken from a letter from Mr. Olmstead to the Secretary of the Commission.

The important lines of investigation so far as can be judged from brief conversations with the Commission and a limited acquaintance with the field are as follows:

RAILWAY FACILITIES.—A study of the freight handling facilities of the Pittsburg district, particularly with a view to forming a reasonable forecast of what enlargements, extensions and changes of the railroad trackage may be looked forward to as necessary for providing the most economical and generally satisfactory means of handling a far greater future bulk of local and through freight than that which has caused so much congestion at busy times in the past. In connection with this study, naturally will be taken up the question of facilities for the long-distance passenger traffic.

This forecast is important not only as a means of enabling the citizens and the municipal officers to adopt a constructive and cooperative attitude in relation to railroad improvements but because the present and expected locations and levels of the tracks and yards react in the most serious manner upon every other feature and aspect of city planning.

The subject is so large and any actual accomplishment is so dependent upon outside railroad interests over which Pittsburg can exercise only a very limited influence that work along this line must be expected to be a tedious process with very little results of popular interest to show for the cost of it during a number of years; yet it is of such fundamental importance and even in its early stages may be of so much indirect value through influencing the location and design of other improvements directly under municipal control, such as streets, bridges, flood protection works, filter plants, parks and so forth, that the citizens ought to be willing to undertake it and patiently back it up.

MAIN THOROUGHFARES.—A study of the problem of main thoroughfares and local passenger railways, primarily from the traffic standpoint, (a) with a view to gradually developing a plan for a broadly comprehensive and adequate system of such thoroughfares and railways for the whole Pittsburg district as a basis for systematic progressive action, (b) with a view to reaching an early conclusion in regard to certain features of such a plan as to which there is the most pressing need of getting immediate practical results, (c) with a view to establishing permanent administrative machinery for bringing about the execution of such a plan and for projecting and extending it.

STREET RAILWAY OPERATION.—A study of the legal and financial problem of how such changes can be brought about in the physical plant and operating methods of the street railway system as are necessary to accomplish, first, a prompt amelioration of the present service, and later the gradual extension and development of the system on the lines of a rational general plan of thoroughfares as above mentioned.

LOCAL STREETS.—A study of the secondary and local streets of the district, as distinguished from the main thoroughfares; to be considered from the point of view of traffic, of real estate development, of economy of maintenance and of influence upon the health and pleasure of the citizens; (a) with the purpose of ascertaining and pointing out in some detail what improvements are generally attainable in the methods of laying out, and in the methods of constructing and maintaining the various classes of such streets; (b) with the purpose of working out an immediate practical program of specific improvements to be made during the next few years in the reconstruction and maintenance of various secondary and local streets in Pittsburg and other municipalities of the district where such improvement is most needed and most expedient; (c) with a view to devising and bringing about the establishment of administrative machinery for the intelligent and effective control of the layout of all new streets of secondary or local character in the various municipalities of the district.

PARKS.—A study of the situation in respect to parks, playgrounds, squares, public buildings and other public properties, with a view to formulating a reasonable, systematic policy as to the distribution thereof and a program of what can expediently be undertaken each year in the way of acquisition of sites and the development thereof during the next years.

FLOODS.—A study, now going on, of the flood problem with a view to preparing a definite plan and program of improvements, correlated with plans for streets and railway improvements and with other features of the gcueral city plan.

WATER SUPPLY AND SEWERAGE.—A study of the problem of water supply and sewerage for the whole Pittsburg Industrial District, with a view to forecasting the requirements of at least the next 50 years, devising a comprehensive general plan for meeting them economically and suggesting where and how the responsibility for doing the work should be placed.

PRIVATE PROPERTY.—A study of the practical results of the existing public control over developments upon private property and over the maintenance thereof (especially in connection with the housing of the people) through building regulations, health regulations and other exercises of the police power and through the incidence of taxation; with a view to determining what changes, if any, can expediently be made in the form or the administration of such regulations and taxes, and whether their application cannot advisedly be correlated more closely with the control of street layouts.

Adequate and comprehensive surveys and records of existing physical conditions being requisite as a basis for any and all thorough comprehensive improvement plans it is needful either to establish a new surveying corps for the district or to enlarge and reorganize the work of existing bureaus.

FINANCE.—Finally a study, with which I do not understand, that Messrs. Freeman and Arnold and I are particularly to concern ourselves, inquiring into the financial, legal and political situation in regard to the raising of funds for works of improvement; with a view to determine (a) what increase, if any, in the current annual expenditure is possible and expedient under existing conditions, (b) what increase of resources, if any, can be brought about by changes in the existing conditions, through economies of administration, increase or alteration of the taxing and borrowing powers, or otherwise.

*[One phase of the work of the Pittsburg Survey was described in Engineering News, June 17, 1909, under the title "Employer's Liability and Industrial Accidents." The scope and results of the survey were published in "Charities and the Commons" now "The Survey," for January, February and March. The work will eventually appear in the publications of the Sage Foundation.]

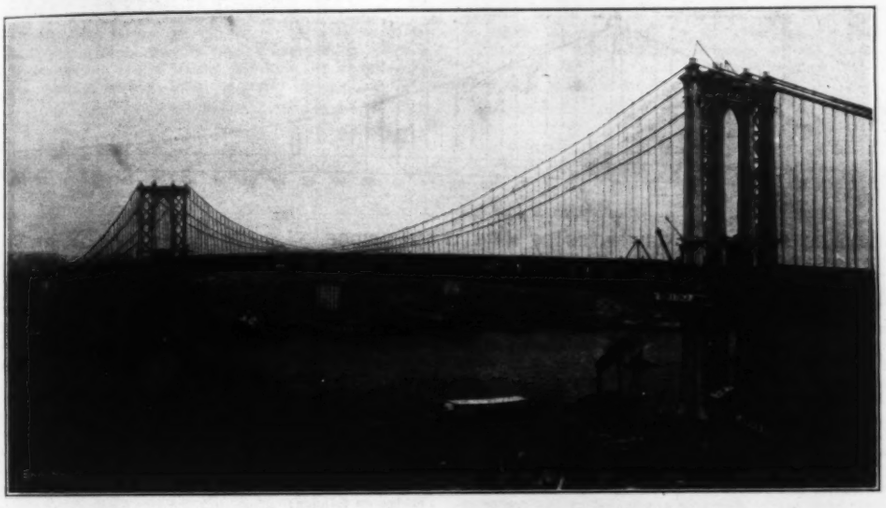
A SUBWAY FOR VIENNA, AUSTRIA, is projected, according to the "Zeitschrift des Oesterreichischen Ingenieur Vereines." This new system, which, if built, will be the first subway in the city, is designed to run in two lines crossing each other at right angles in the center of the city. The project at present calls for municipal ownership and the construction of a large power plant, from which light and power are to be sold.

Modjeski's Report on Design and Construction of the Manhattan Bridge Over the East River at New York City.

At the time the investigation of the Blackwell's Island Bridge (Eng. News, Nov. 12 and 19, 1908) was under way, doubts were raised also as to the strength of the fourth East River Bridge, now nearly completed. This is a wire-cable suspension structure known as the Manhattan Bridge. The doubts and suspicions were brought to official notice by a letter from a civic society to the Mayor, wherein an investigation by an outside engineer was requested. In consequence Mr. Ralph Modjeski, M. Am. Soc. C. E., was retained by the city to investigate the design and execution of the bridge fully.

Mr. Modjeski's report, completed a few weeks ago, and reprinted below, gives the new bridge a clean bill of health.

RESULTS.—The superstructure is approved as sufficient and excellent, with the single reservation that the riveting of some joints of the stiffening trusses may prove slightly weak under reversed stresses so as to need occasional redriving. This is not at all a vital matter.



The Bridge Seen from the Brooklyn Shore.

The substructure of the Brooklyn side is approved without reservation.

The foundation of the tower pier on the Manhattan side is criticized mildly, but passed as acceptable.

The Manhattan anchorage is subjected to rather stronger criticism, because the increasing cable pull has moved the mass of masonry perceptibly toward the river. But on close observation of the amount of this shifting Mr Modjeski reaches the opinion that the anchorage is reliable.

From a copy of the report obtained by courtesy of Mr. A. Johnson, Consulting Engineer for the bridge, we reproduce the text of the report in full, and the most important of the drawings which accompany it. We add two photographic views, from the progress files of the Department.

The report is addressed to the Commissioner of Bridges of New York City.

Report on the Manhattan Bridge.

In accordance with your request and instructions, under date of Jan. 26, 1909, I beg to submit to you my report on the design and construction of the Manhattan Bridge.

Work on this report was started in January and pursued continuously until now. A force of men in your department was employed on accurate calculations of actual dead-loads and later on the stresses of the stiffening truss and towers. My assistant, Mr. W. R. Weidman, was placed in charge of this force, and under instructions from me directed operations as well as supervised various investigations and experiments. I also put a force of men at work in my Chicago office to make certain computations independently and to check those made by the New York office. The Chicago force was at work under my supervision and under advice of Prof. F. E. Turneaure, of the University of Wisconsin. I made numerous visits to the New York office, keeping personally in touch with the work being done there, and I made several visits to the work, examining its progress and methods of construction.

The following computations and investigations were performed in order to obtain results necessary for this report:

Calculations of pressures on, and stability of masonry and foundations; Observations by careful measurements of the settlement and horizontal movement of anchorages and of the settlement of tower piers; Examinations of records of construction to determine the character of foundations; Accurate calculations and tabulation of weights from actual working plans and checking them by comparison with shipping invoices; Calculations of trusses and steel towers based on corrected values of dead-loads and cable pull; Calculation of stresses in cable and stiffening trusses based on corrected values of dead-load; Calculation of ordinates of the equilibrium polygon of the cable with panel concentrations corresponding to actual dead-load for comparison with the parabola assumed in the formulas; Calculation of the floor system; Calculation of the lateral system; Checking of the strength of all details in the superstructure; Investigation of inspection performed at the mills and shops; Checking of main sections of material in the bridge by actual measurements; Making tests of cable wire; Making experiments to determine the conductivity to heat of the main cables; Making measurements of coefficient of expansion of cable wire; Preparing various drawings to show results of computations and experiments; Tabulating results of specimen tests of carbon and nickel-steel for the purpose of ascertaining the average resistance of the material and its uniformity; Calculating moments in the stiffening trusses due to "combined" loading for the purpose of comparing the results with those due to "congested" loading, the combined loading being taken as a maximum which may actually occur under certain exceptional conditions; Calculating briefly, the effect of closing the trusses at a temperature of 30° higher than normal with incomplete dead-load.

Your Department gave me free access to all records and extended to me every possible assistance and courtesy.

Features of the Bridge.

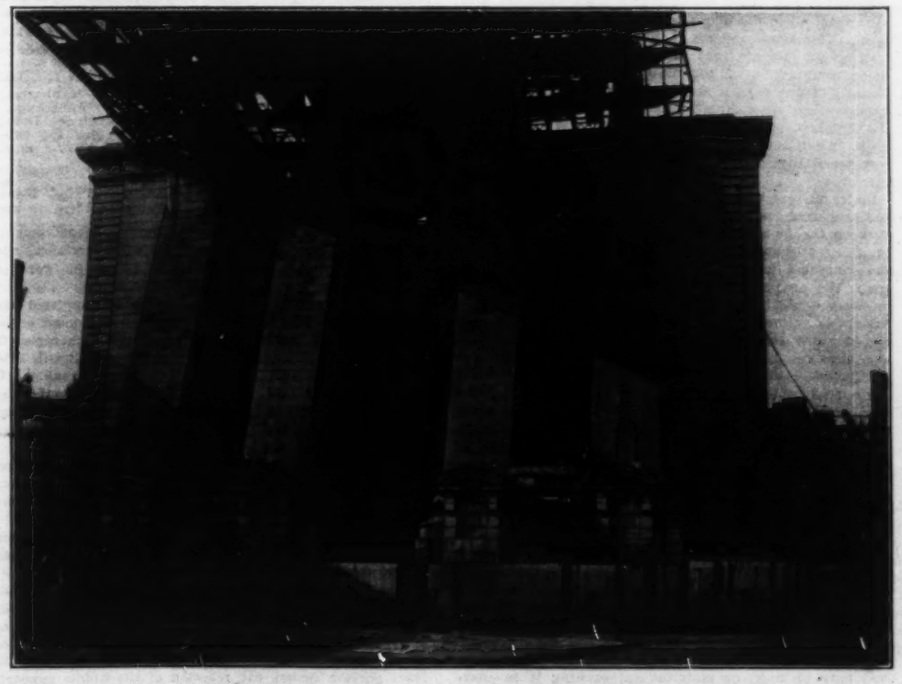
Briefly described, the Manhattan Bridge is a structure of suspension type, with four cables hanging in vertical planes, carrying four stiffening trusses. The cables are supported by two steel towers and are anchored at ends in masonry abutments. The main span is 1,470 ft. long center to center of towers and each side span is 725 ft. long from center of tower to center of shore end support. The steel towers are fixed to the piers and are designed to deflect under varying loads and temperature conditions; the saddles carrying the cables are fixed to the top of the towers; the trusses are continuous from tower to tower and from tower to anchorage abutments; the ends of the trusses are anchored down, but provision is made for a longitudinal movement at the towers; the lower floorbeams are continuous and rigidly attached to the trusses; the upper floorbeams are placed between each pair of trusses only. Provision is made for eight railway tracks, one roadway and two sidewalks. The tracks are located between each pair of trusses on both decks, the roadway between the two inner trusses and the sidewalks on brackets outside of the outer trusses.

The towers and the floor and lateral systems are of carbon steel; the trusses are of nickel-steel; the cables are of carbon-steel wire.

Substructure.

At the time I was requested to make this report, the masonry of both tower piers had been entirely completed, and the masonry of both anchorages had been completed with the exception of some concrete work around the anchor bars and in the small arches supporting the roadways, and with the exception of some ornamental work. The steel towers were completed and the main cables partly strung. The remarks which follow regarding the substructure are therefore based on the data secured by examining the records of construction, as well as on personal observation of the finished work.

TOWER PIERS.—The Brooklyn tower pier foundation rests on a bed of boulders and cemented gravel which overlies the bedrock to a depth of from two to three feet. The cutting edge of the caisson is at elevation —91.85 or about 62 ft. below the river bottom. The



The Anchorage at the Manhattan End, Seen from the River Side.

TWO RECENT VIEWS OF THE MANHATTAN BRIDGE OVER THE EAST RIVER.

records show this material to be such as to "require a pick to loosen it" and perfectly reliable as a foundation. I believe the engineers were fully warranted in stopping the sinking of the caisson in this material instead of going deeper to bedrock.

That this foundation is of an unyielding character may be seen from the record of levels taken on top of the pier from time to time since the coping was laid until June 16, 1909, when the steel towers, cables, and most of the superstructure, were in place. The total settlement at the coping during that period was only ¼-in., which is about the amount a pier of this height would be expected to compress under load if placed on an unyielding foundation.

The Manhattan tower pier foundation rests in compact sand and gravel at an elevation of —92.26. Some of this sand, perhaps 5%, is reported to be very fine and apparently a considerable amount of moderately fine sand has been found at the elevation where the sinking was stopped. Borings taken at the site of this pier indicate rock or boulders at elevation from —100 to —129, which is from 8 to 37 ft. below the cutting edge of the present foundation. In order to get an all-rock foundation it would have been necessary to sink the pier some 25 to 30 ft. further, which would have been a difficult and expensive matter. The quantity of fine sand between the bottom of the caisson and rock, as indicated by the borings, is not sufficient to place any serious doubt on the efficiency of the present foundation, yet there is a security and reliability about a rock foundation which in important work it is often advisable to reach, even at a considerable increase in cost.

Recent levels taken on this pier show that the total settlement since the pier was completed is approximately ½-in. This small amount of settlement under increasing load would indicate that the foundation is satisfactory. Some compression of the material under the pier, especially of fine sand if saturated with water may usually be expected. By comparing this settlement with that of the Brooklyn pier it would appear that the difference of ¼-in. in settlement of the two piers is due to the greater compressibility of the material under the Manhattan caisson.

Under an extreme condition of loading, namely, with the congested load covering the entire bridge, the pressure on the foundation of the piers will be 8.4 tons per sq. ft.; while under the improbable loading consisting of the congested load on the main span and the far-side span, the near-side span carrying no load at all, this pressure would become 9.2 tons per sq. ft. In the above calculation allowance is made for the uplift due to displaced water (and not wet sand, as is sometimes done), also the skin friction in sand assumed to be 500 lbs. per sq. ft.; account is taken of the unbalanced horizontal cable pull at the top of the tower, and a conservative deduction made for the resisting moment of the earth pressure. The pressure of 9.2 tons would occur at one edge of the caisson, the average for that case of partial loading being 7.7 tons per sq. ft.

It should be borne in mind that the above conditions of loading are so improbable that it is safe to say they will never be realized, but should they occur it will be only for a relatively short period of time and their effect on the foundation will be of no importance.

It might be well to remark that during erection the pressure on these foundations has reached about 7 tons per sq. ft.

ANCHORAGES.—No part of a suspension bridge is more important than the anchorages and their foundations. An ideal or unyielding foundation can be realized only in rock, or material approaching it in character. In any other material a certain amount of displacement in anchorages when subjected to the pull of the cable may reasonably be expected. It is well known that a displacement or settlement of one or more supports in a suspension bridge creates corresponding disturbances in the superstructure stresses. It is therefore of the utmost importance to construct the supports in such a manner as to reduce such displacement to the minimum.

The excavation of the foundation of the Brooklyn anchorage was carried down into a stratum of boulders, gravel and sand which even without piles would probably have offered sufficient resistance to sliding. Some piles were driven, however, but on account of boulders the driving was difficult and the piles did not as a rule have the desired penetration. Yet, on the whole, this foundation seems to be very satisfactory, and the measurements taken and referred to later show that the movement of this anchorage under the gradually increasing pull of the cables has been very small and that no appreciable movement has taken place since two months.

The Manhattan anchorage is founded on sand and closely-driven vertical piles. This foundation is less effective in resisting horizontal displacement than the one on the Brooklyn side, principally on account of the different character of material under it. It is generally desirable, where the resultant pressure on a pile foundation deviates considerably from the vertical, to drive at least a part of the foundation piles at an angle approaching as nearly as possible the angle of the resultant. Although the horizontal motion which has taken place in this anchorage is too small to influence the stresses in the cables and suspended spans appreciably, this motion could have been reduced or eliminated by the use of inclined foundation piles.

The total movements of the respective anchorages since the erection of the stiffening trusses was begun are shown in the table below. The horizontal movements which occurred previous to that time had not been recorded.

RECENT MOVEMENTS OF ANCHORAGES, IN INCHES.

	Brooklyn Anchorage. Since Mar. 1, 1909.	Brooklyn Anchorage. In last two mos.	Manhattan Anchorage. Since Mar. 1, 1909.	Manhattan Anchorage. In last two mos.
Horizontal movement, base.	5/16	None	13/16	1/16
Horizontal movement, top...	3/4	None	1	1/4
Settlement, front.....	1 9/16	1/16	1 13/16	None
Settlement, rear.....	1 13/16	3/16	1 9/16	1/16

Even under most favorable conditions, measurements of this kind are difficult to make with precision, and the above figures are the results of as careful work as could be obtained.

It is probable that when the bridge is completed and the cables are subjected to nearly their maximum stress the horizontal movement of the Manhattan anchorage will cease entirely, and I do not apprehend that it will ever become of sufficient importance to cause trouble. It should be noted that the greater part of the horizontal movement of this anchorage occurred before the masonry was quite completed and therefore before it had all its weight.

Assuming each anchorage acting as a whole, the pressure on the foundation at the toe under maximum conditions of loading will be 7.5 tons per sq. ft. These pressures are within safe limits.

I have also calculated the anchorages assuming each anchorage cut through the arch and the two parts acting independently to resist the stresses due to the cable strain and their own weight. Each part is therefore calculated with the other part removed. The rear portion resists the cable pull on the anchorage; the resultant pressure. The pressure of 9.2 tons would occur at one would range from 2.7 tons to 9.4 tons per sq. ft. The front portion resists the reaction of the saddle supporting the cable and the resultant pressure would range from 6.1 tons to 7.8 tons per sq. ft. The above figures are, of course, based on conditions which do not exist, but they show that each portion separately would, barring settlement, remain in equilibrium under the cable stresses.

The internal stresses and reinforcements have also been checked and found correct.

From personal observation of the finished work and from the examination of records, I can say that none but first-class work has been done on the entire substructure and that it has been constructed in accordance with the requirements of the specifications. I have carefully examined the plans and specifications for the piers and anchorages and find they have been carefully and correctly drawn.

Superstructure.

SPECIFIED LOADS AND STRESSES.—For convenient reference paragraphs 119 to 123 of the specifications are reprinted in Appendix A [see below.—Ed.]. The live-load assumed for proportioning this bridge is the same as that recommended in the report of bridge experts, dated March, 1903. It is true that since that report was written heavier cars than those assumed therein have come into use, and that by selecting the heaviest cars, packed with people, placing them on the four tracks in uninterrupted lines, without intervening space between the ends of consecutive cars or trains, packing the footwalks with people, the trolley tracks with continuous lines of heaviest crowded street cars and the roadways with heaviest vehicles, it would be possible to obtain a *theoretical* loading of 18,300 lbs. per ft. of bridge as follows:

MAXIMUM THEORETICAL LOADING.

Four lines of Long Island R. R. cars crowded with people, at 2,000 lbs. per lin. ft.....	8,000 lbs.
Four continuous lines of Brooklyn R. T. cars crowded with people, at 1,500 lbs. per lin. ft.	6,000 "
35.5 ft. of roadway at 75 lbs. per sq. ft.....	2,650 "
Two sidewalks crowded with people at 75 lbs. per sq. ft.....	1,650 "
	18,300 lbs.

This is purely a theoretical loading, however, and can not possibly be realized in practice. The loading of 16,000 lbs. per foot of bridge, considered as a maximum practical loading that may ever be placed upon the bridge, is quite ample, and will provide for a considerable future increase in weight of rolling stock. One-half of the above taken as "regular" or "working" load combined with the maximum effect of wind and temperature is also quite sufficient, as it will be seen that under very heavy regulated traffic, such as may happen at certain hours of the day, this loading is far from being realized.

HEAVY REGULATED TRAFFIC.

Two lines of six-car trains crowded with people, running 500 ft. apart.....	1,640 lbs.
Two lines of six-car trains, as above, but running in opposite direction empty.....	1,320 "
Two lines of surface cars filled with people, running a car length apart.....	1,500 "
Two lines, as above, empty.....	1,240 "
Roadway, two lines of vehicles at 300 lbs. per lin. ft.....	600 "
Sidewalks, 22 ft. at 30 lbs. per sq. ft.....	660 "
	6,960 lbs.

No provision has been made in the specifications for the weight of snow, and none should be made, as unless the snow is kept removed from the roadways and footwalks, as it should be, a quantity of it sufficient to influence the stresses would considerably reduce or entirely stop the vehicle and pedestrian traffic.

On examining the unit-stresses allowed by the specifications for proportioning the stiffening trusses, as applied to nickel-steel, one is impressed at once with their apparently high value. But the unit-stress is only one of the two functions which determine the size of a bridge member, the other function being the assumed loading.

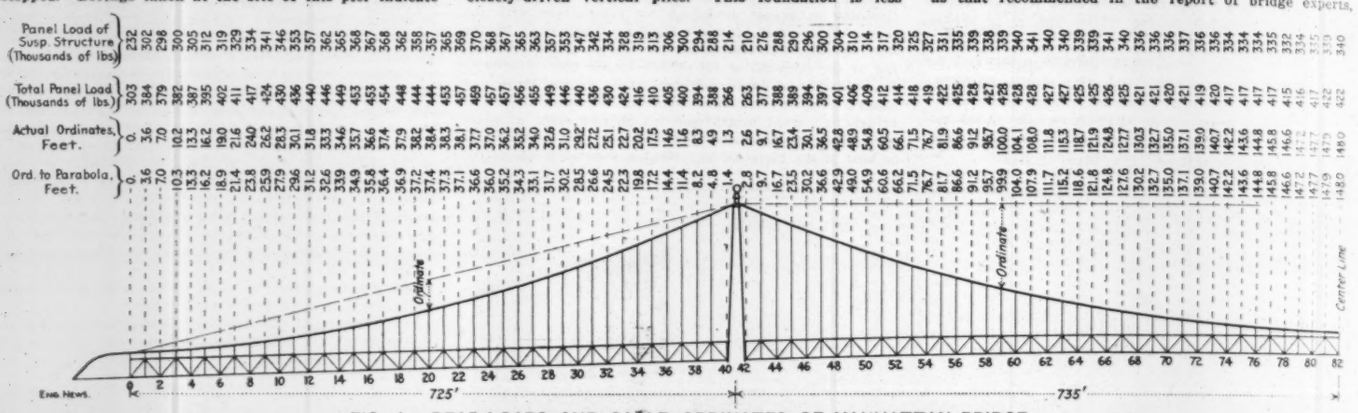


FIG. 1. DEAD-LOADS AND CABLE ORDINATES OF MANHATTAN BRIDGE.

The upper load figure is the weight below suspender ropes, for the finished bridge.
The lower load figure includes in addition the weight of suspender, cable-band, cable, serving wire, etc.
The upper ordinate is measured to the actual equilibrium polygon for the above dead-loads.
The lower ordinate is measured to a true parabola.

To produce the maxima stresses in the trusses involves in each case loading a certain section of the bridge to its full capacity while the remainder of the bridge must have no loading on it whatever. I consider, therefore, the high units adopted by the specifications for tension and compression in the truss members together with the well-nigh impossible conditions of loading as one of many possible methods of proportioning the members, but this does not mean that the metal in actual service will be subjected to those stresses. Should a condition of loading approaching the maximum occur, it would be only at rare intervals, and as the allowed stress is less than four-fifths of the elastic limit, the metal would not be over-stressed. It should be added that the stiffening truss differs from an ordinary bridge truss, in that any truss member may sustain an injury without in the least endangering the structure as a whole.

Recently, experiments were made for the Board of Engineers of the Quebec Bridge on nickel-steel riveted joints, in which the series of tests made by the American Engineering and Maintenance of Way Association on carbon-steel riveted joints (Vol. 6 of Transactions), was reproduced in nickel-steel. These tests show that the ultimate shearing strength of nickel-steel riveted joints exceeds that of carbon steel by from 8.4% to 22.7%, with an average of 16.4%, when reduced to shear per square inch of rivets; further, that the average shear on nickel-steel rivets in joints at the yield-point may be taken at 30,000 lbs. per sq. in., or 50% greater than the unit allowed by the specifications.

These tests further show that in joints of about the same thickness as those in the top and bottom chords of the Manhattan bridge trusses, the first slip of the plates was detected at from 9,500 to 14,670 lbs. per sq. in. of rivets in field-riveted joints, and from 10,500 to 18,000 lbs. per sq. in. of rivets in shop-riveted joints. The field riveting was done by a pneumatic hammer and the shop riveting by a pressure machine. Had these results been available at the time the specifications for this bridge were drawn, no doubt some allowance for reversal of stresses in riveted joints would have been made. This will be discussed later in connection with details.

INSPECTION OF MATERIALS AND ERECTION.—At the time I was requested to prepare this report, practically all wire and all other metal work had been manufactured and the erection in the field was in progress. As far as mill and shop inspection was concerned it remained for me to gather such information as was available as to how the material had been manufactured, and if the inspection had been efficiently performed at the mills and shops.

I, therefore, requested Mr. W. E. Angier, M. Am. Soc. C. E., as representing me, to visit the following plants: Carbon Steel Co., at Pittsburg, Pa., who had the general contract to furnish the entire superstructure of the bridge; the Phoenix Iron Co. and the Phoenix Bridge Co., at Phoenixville, Pa., who had the sub-contract for rolling steel shapes and for the fabrication of the material; the Roebling plant, at Trenton, N. J., which furnished all the steel suspender cables and the wire for the main cables.

At the above plants the respective inspectors, who were in charge at the time the material was being manufactured, as well as officials and employees of the manufacturers, were interviewed and questioned as to the various phases of manufacture and inspection; records were examined, and mill and shop facilities and testing machinery inspected and, judging from the report of the trip, I am satisfied that all of the material furnished for this bridge was very carefully and thoroughly inspected at all stages of manufacture, that it is up to the specifications, and that the shopwork is of the very best character.

Strength of Material.

TESTS OF STRUCTURAL STEEL.—The specifications require that all carbon steel, except eyebars and pins, develop in specimen test an elastic limit of 33,000 lbs. per sq. in. and an ultimate strength of 60,000 to 68,000 lbs. per sq. in. The corresponding requirements for nickel-steel are 55,000, and 85,000 to 95,000 lbs. per sq. in. From actual test-records of all of the material used in the bridge, tables were prepared showing maximum, minimum and average elastic limit and ultimate strength of all tests for each thickness of metal. It will be seen that the material complies with the requirements and that the averages are considerably higher. The test reports were also examined as regards the chemical and other physical requirements, and indicate that all accepted material is well within the specifications.

[Without reproducing these tables in full we may summarize them thus:

	Range of Elast. Lim.	Range of Ult. Str.
Carbon steel:		
Plates, ¼-in. to 1¼-in.	32,300 — 46,300	58,400 — 69,200
2½-in.	30,500 — 40,600	55,300 — 64,100
Rolled shapes	37,700 — 45,800	60,200 — 68,100
Rivet rods	29,700 — 43,000	48,900 — 72,300
Nickel-steel:		
Plates, ⅞-in. to 1-in.	50,300 — 63,100	80,600 — 102,100
Rivet rods	55,200 — 56,400	72,700 — 79,500

—Ed.]

TESTS OF CABLE WIRE.—These specifications further require that the wire for cables and ropes have an ultimate strength of not less than 215,000 lbs. per sq. in. before galvanizing, and not less than 200,000 lbs. per sq. in. of cross-section after galvanizing. I thought it desirable to determine, if possible, the elastic limit of this wire; consequently samples were taken from the bridge and tested at the University of Illinois. The results of tests are given below [see also Fig. 2.—Ed.]. The yield-point of the wire ranges from 136,500 to 138,000 lbs. per sq. in., and the ultimate strength from 210,400 to 215,200 lbs. per sq. in. on the gross area, including galvanizing; the reduction of area at the fracture ranges from 23% to 31.4%. These results show that the wire is of excellent quality.

TENSILE TESTS OF SAMPLES OF WIRE.

Furnished by Ralph Modjeski, from that used in cables of the Manhattan Bridge. Diameter of wire = 0.198 in.

	Pounds per Square Inch					
Number of test	1	2	3	4	5	Average.
First measurable set:						
Wire as received	45,000	46,000	43,500	.....	.....	44,830
Second application of stress	.....	.....	119,500	.....	.....	119,500
Limit of proportionality (wire as received)	72,500*	.....	83,500*	109,000†	107,000†	78,000* 100,000†
Yield-point	.....	136,500	131,500	.....	.....	138,000
Ultimate unit stress	212,300	212,200	215,200	210,400	212,000	212,400
Elongation in 8 ins.	.....	.....	.....	3.50%	4.63%	4.065%
Reduction of area at fracture	31.4%	27.2%	23.0%	24.7%	25.2%	26.30%

*Elongation measured over 8-in. gage length with Ewing extensometer reading to 0.00002-in.
†Elongation measured over 2.5-in. gage length with Ames test gage reading to 0.0001-in.
Note.—The higher values of the limit of proportionality obtained in tests 4 and 5 are due to the fact that the sensitiveness of the extensometer was only one-sixteenth as great as in tests 1 and 3.

FULL-SIZE TESTS OF SUSPENDER ROPES.—The suspender ropes were tested for the Department of Bridges: four tests developed an ultimate strength ranging from 209,640 lbs. to 214,470 lbs. per sq. in. of wire, the area being measured before galvanizing. The elastic limit is said to be about 60% of the ultimate, in the highest test, or about 130,000 lbs. per sq. in. In all cases the sockets broke the rope. As the unit stress allowed by the specifications is 30,000 lbs. per sq. in. these suspender ropes have a very large margin of safety. The ultimate strength of the rope, as given above, is below the limit stated by the specifications, but the latter is not interpreted as applying to the finished twisted rope but to single wires. [The wire is the same as used for the main cables, so that the table just above and Fig. 2 describes the strength of the suspender wire as well as the cable wire.—Ed.]

ERECTION.—During my visits to the bridge I examined the work and repeatedly watched the erection and riveting. I have also had a general oversight kept on the work and I am satisfied that all work done in the field is of the very best character.

Towers.

The method used in calculations of the steel towers is outlined in Appendix C, and the results of the calculations are shown on Plate 8. [Fig. 3.—Ed.] Congested live load was assumed at 4,000 lbs. per ft. on each cable. By loading one side of the bridge with congested load it would be possible to obtain a load of 4,500 lbs. per ft. on the outside cable and the stresses in the tower would thereby be increased by from 4.5 to 5%. I do not think that the specifications could be interpreted to require such abnormal positions of load, otherwise by loading one side of the main span and the other side of both end spans the difference in deflection at the center of the main span between the two outside cables would be about 15 ft., producing a transverse grade of over 15%. It is obvious that such a condition would never arise or never be permitted to rise. The fact that the towers resist bending as well as direct compression makes the calculations more certain than if they were acting as simple columns. These towers are amply strong to perform their duty.

Cables.

The method used in calculation of maximum cable stresses is also given in Appendix C.

The coefficient of expansion of cable wire was assumed to be .0000066. Since the calculations were completed

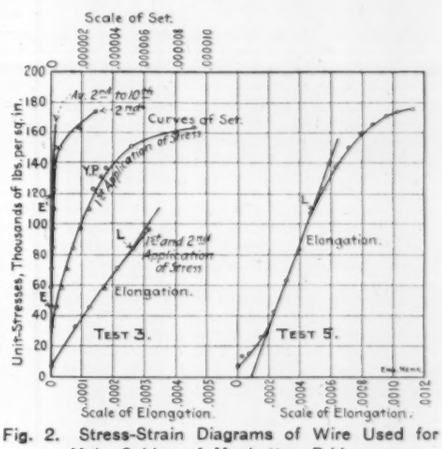


Fig. 2. Stress-Strain Diagrams of Wire Used for Main Cables of Manhattan Bridge.

E = Point of first measurable set.
E' = Point of first measurable set on second application of stress.
L = Limit of proportionality of elongation to stress.
$Y.P.$ = Yield-point.

(Note: The same size and kind of wire was used for the suspender ropes, but these are twisted ropes. Four of these ropes were tested to failure in full size, with end sockets, as stated in text, giving ultimate strengths of 209,640 to 214,470 lbs. per sq. in. of wire.)

I had experiments made under the direction of Prof. Turneaure, of the University of Wisconsin, to determine the true coefficient of this wire. For this determination a sample of the cable wire 80 ins. long was placed in a brass tube of 1¼-in. diameter. Through this tube water was circulated at different temperaturts and measurements of elongation made by means of extensometers reading to 0.0001-in. Four sets of observations were made, two for increasing temperature between 25° and 79° C., and two for decreasing temperature between about the same limits. The calculated coefficients for those four runs reduced to Fahrenheit were as follows:

EXPANSION COEFFICIENTS OF CABLE WIRE.

	Expansion per degree F.
(1) Up coefficient	.00000004
(2) Down coefficient	.00000004
(3) Up coefficient	.00000002
(4) Down coefficient	.00000003
Average	.00000003

Assuming the coefficient to be .000000, this is 9% less than the coefficient which has been assumed in the calculations, consequently the temperature stresses would be reduced by approximately that amount.

DIURNAL TEMPERATURE VARIATIONS OF CABLES.—To get some idea of how closely the average temperature in the cables follows that of the air, I had the following experiments made: Two large glasses were cut vertically through the center and the halves attached to each side of two cables in such a manner that they would hold water and that this water would be in direct contact with the steel wires of the cable. This method is similar to the one which has been used at the Forth Bridge. The receptacles were properly sheltered from the weather and the rays of the sun. Diagram [Fig. 4.—Ed.] shows results of hourly thermometer readings over a consecutive period of 48 hrs. It would appear from those experiments that the mean temperature of the cable does not attain that of a surface exposed to the rays of the sun. It is also interesting to note that at night, although both sides of the cable are nearly at the same temperature, this temperature is by several degrees higher than that of the air; in other words, the mean temperature of the cable does not go through the same range of variation as the air. When it is considered that the temperature of the air in New York City may commonly vary from 10° below zero to 120° in the sun, the variation assumed in the calculations, from 0° to 110°, seems to be very nearly correct.

CABLE STRESSES.—Assuming one side of the entire bridge loaded with congested load, which, as has been said, would be an improbable condition, the load on the outside cable would be 4,500 lbs. per lin. ft. This gives at lowest condition of temperature a maximum stress of 71,450 lbs. per sq. in. There is generally a certain number of loose wires in the cables; assuming these to be 3% of the whole, and assuming, further, that the secondary stresses due to bending in the cables near the saddles will be 10%, the above stresses will be increased by 13%, giving 80,738 lbs. per sq. in. as the maximum theoretical cable stress. As the yield point of the wire is about 130,000 lbs. per sq. in., the cable has a large margin of safety.

Stiffening Trusses.

By far the most laborious calculations in a suspension bridge of this type are those of the stiffening trusses.

The so-called *exact* method, which takes account of the deflections, has been used originally by Mr. Moisseiff, of your department, who did excellent work in developing Melan's "Genauere Theorie" into formulas which can readily be applied to all cases of loading. On taking up the recalculations I first had the actual dead-loads computed from working plans, the results being shown on Plate 1 [Fig. 1.—Ed.] They were found to be remarkably close to, and slightly below, the dead-loads assumed in former calculations. These formulas and the corrected dead-load were used by the New York force placed under my direction in preparing an entirely new set of figures. The same dead-load was used by the Chicago force, but formulas developed by Prof. Turneaure, specially for this work (see Appendix B), which are more convenient to use for determining the horizontal cable pull for all conditions of loading, were used, and the two series of figures checked each other. The results were found to be identical.

In computations of this kind it is necessary to make certain assumptions which do not affect the correctness of the results appreciably.

The cable curve under full dead-load is assumed to be a parabola. On Plate 1 [Fig. 1.—Ed.] are shown the exact dead-loads distributed to each panel point, from which an equilibrium polygon has been calculated for the main and the side spans. The ordinates of these polygons and of the true parabola [given for each panel-point in Fig. 1.—Ed.] differ so little that the assumption of the parabola, while not mathematically exact, may be considered sufficiently close for all practical purposes.

The moment of inertia of the trusses used in the formulas has been determined by calculating the moment of inertia of the chords alone and adding thereto a correction for the effect of the web system, this correction being determined by deflections and equal to 8.5% for the side spans, and 8.2% for the main spans.

The moment of inertia was assumed uniform for each span. In order to check the correctness of this assumption, calculations were made for variable moments of inertia, as follows: The moment of inertia of the main span was assumed as uniform from the ends of the quarter-point, using an average value, and then uniform from the quarter-point to the center; the moment of inertia of the side span was assumed at four different values for each half. Under these assumptions the following bending moments were obtained:

	M for Variable I.	M for Constant I.
Main span, center	91,250,000	88,350,000
Quarter point	113,960,000	118,000,000
Side span, center	185,560,000	179,900,000
Quarter point	139,200,000	138,000,000

These results do not vary sufficiently to make it necessary to carry out the calculations on the assumption of variable moment of inertia.

The extension of the suspender cables was neglected in the computations; to take account of it would involve extremely laborious calculations which, in view that the error committed is insignificant, would not be warranted.

The resistance of the cables to bending is neglected. This assumption is on the safe side, and the error is of no importance.

The resistance to bending of the towers is neglected. The action of this resistance is to relieve the maxima stresses in the trusses and is comparatively small.

Figs. 5 and 6 show curves of greatest bending moments and shears.

On Fig. 5 will be noticed curves for moments due to "combined" loading. This loading would, in my judgment, be the practical maximum which the bridge will ever be called to carry in regular service. It consists of a uniform load of 8,000 lbs. per ft. covering the entire bridge, and the additional loading of 8,000 lbs. per ft. placed so as to produce the greatest stresses. It will be seen that this condition compares very favorably with the congested loading assumed.

Details of Design.

TRUSS JOINTS AND SPLICES.—The splices and riveted connections of the main trusses are of such importance that they can hardly come under the head of details. In discussing the specifications I have shown that an initial slip between plates of a riveted joint occurs at a much lower stress per square inch of rivets than the allowable shearing stresses which generally appear in the specifications. While in joints subjected to a stress in one direction only, a slight amount of slip between the plates is of no practical consequence, this slip being dotected only by very sensitive measuring instruments, it is not so with the joints subjected to reversal of stresses. It is more than probable that the shearing stress of 20,000 lbs. allowed in the specifications for this bridge will never be attained, but it is quite possible that stresses greater than those required to produce an initial slip will be of frequent occurrence in some joints. Of course the worst that could happen is that rivets subjected to reversal of stress under those conditions would become gradually loose and may have to be replaced from time to time. If such joints had been proportioned for a more conservative unit-stress the chances for loosening of rivets under reversal of stress would have been avoided, or considerably reduced.

I have carefully examined all other details and connections and find them in accordance with good practice, and in harmony with the structure.

Floor and Laterals.

FLOOR SYSTEM.—Paragraph 119 of the specifications, which stipulates that the load is to be placed on the bridge so as to give the greatest stress in each part of the structure, cannot be applicable to floorbeams made continuous over the whole width of the bridge, for the reasons given in connection with the towers and cables. The continuous floorbeams are subjected to stresses resulting from three sources, namely, dead load, cable reactions and concentrated load. In case the floorbeams were made discontinuous the cable reactions would be eliminated. I have calculated these floorbeams for a condition which is extreme yet consistent with the distribution of loads assumed for the calculation of the stiffening girders. A load of 14,250 lbs. is assumed to be placed on one side of the main span, while the other side of the main span has no live load whatever. This corresponds to loading the outside cable with a continuous load of 4,050 lbs. per ft., which is slightly in excess of the load for which the trusses were figured. This condition develops a flange stress of 9,900 lbs. per sq. in., or slightly under the specified unit. If, in addition to the above, the concentrated load "C" [shown on the diagram in the table below.—Ed.] be applied, the flange stress will be 11,440 lbs. per sq. in., which is considerably within safe limits. It should be noted that the loading "C" is in excess of the concentrated loading as required by the specifications. I consider, therefore, these floorbeams as safe and as meeting any reasonable interpretation of the specifications. Other parts of the floor,

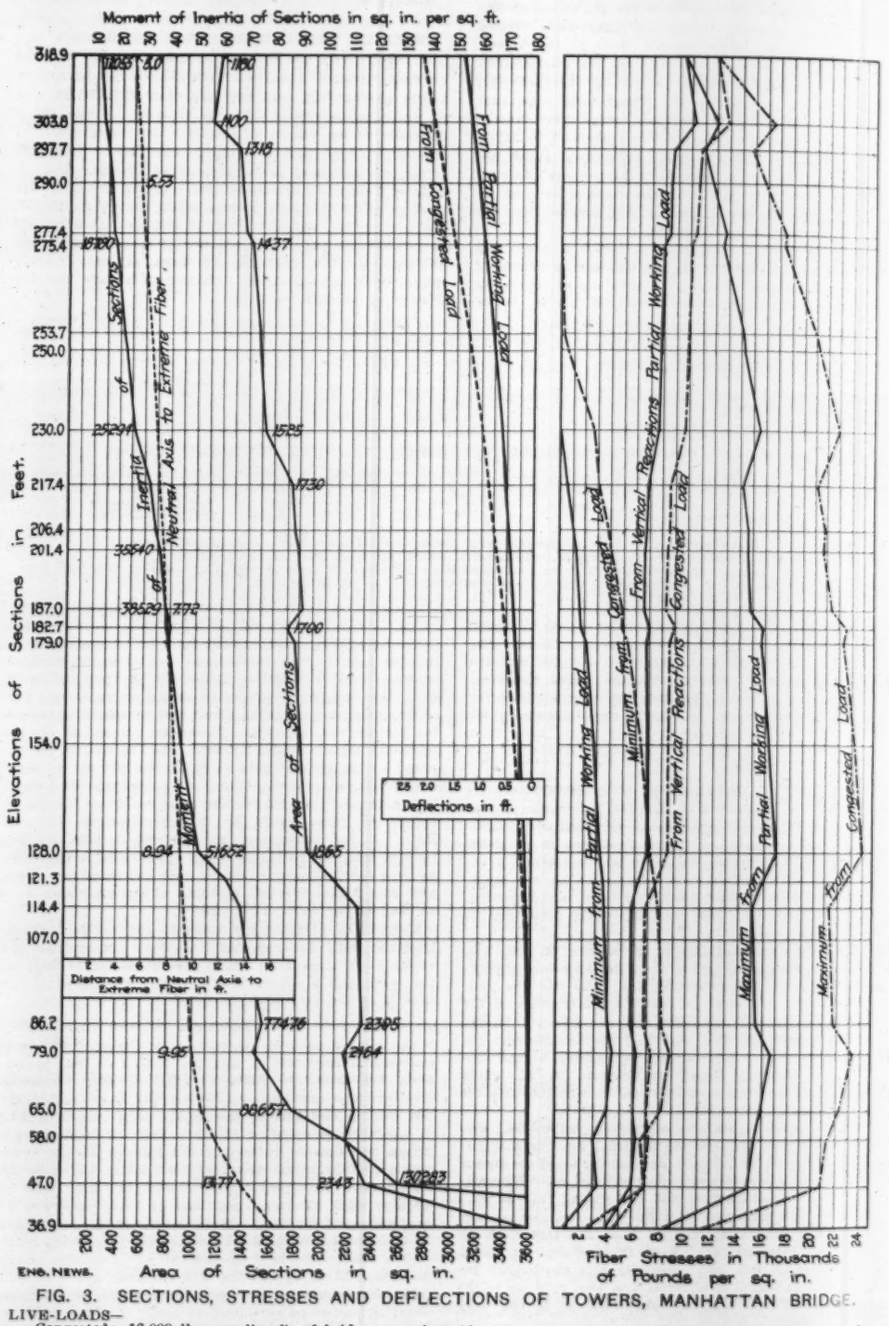

Moment of Inertia of Sections in sq. in. per sq. ft.
Elevations of Sections in Feet.
Area of Sections in sq. in.
Deflections in ft.
Distance from Neutral Axis to Extreme Fiber in ft.
Fiber Stresses in Thousands of Pounds per sq. in.
From Congested Load
From Partial Working Load
Moment of Inertia of Sections to Extreme Fiber
Neutral Axis
Area of Sections
From Vertical Reactions Partial Working Load
From Vertical Reactions Congested Load
Minimum from Partial Working Load
Minimum from Congested Load
Maximum from Partial Working Load
Maximum from Congested Load
ENG. NEWS.

FIG. 3. SECTIONS, STRESSES AND DEFLECTIONS OF TOWERS, MANHATTAN BRIDGE.

LIVE-LOADS—

Congested: 16,000 lbs. per lin. ft. of bridge, covering sidewalks and tracks on both sides and roadway. Each cable carries 4,000 lbs. per lin. ft.

Partial: 9,775 lbs. per lin. ft. of bridge, covering sidewalk and tracks on one side only and the roadway (central). The outside cable carries 2,200 lbs. per lin. ft.

CABLE REACTIONS at saddle (El. 318.9 ft.).

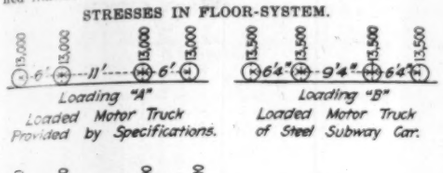
	Vertical.	Horizontal.
Congested Load	13,332,000	330,000 lbs.
Partial Load	10,956,000	232,0'0 lbs.

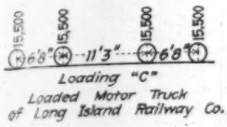
TRUSS REACTIONS at truss seats (El. 121.3 ft.).

Congested Load	Side span, up,	849,400 lbs.
	Main span, down,	211,300 lbs.
Partial Load	Side span, up,	495,400 lbs.
	Main span, down,	136,700 lbs.

both upper and lower, as well as their connections, are also shown by the following table to be within the specified limits:

STRESSES IN FLOOR-SYSTEM.





	Lbs. per sq. in. Loading. A.	Loading. B.	Loading. C.	Allowable.
Upper Deck Stringers.				
Flange (incl. I of web)	8,400	8,550	9,500	10,000
Web shear (net sec.)	2,560	2,720	2,860	7,000
Fl. riv., shear	4,200	4,400	4,810	7,000
Fl. riv., bearing	5,650	6,900	7,550	14,000
Upper Deck Floorbeams.				
Flange (incl. I of web)	9,270	10,270	10,015	10,000
Web shear (net sect.)	6,400	7,150	6,975	7,000
Fl. riv., shear	4,750	5,350	5,200	7,000
Fl. riv., bearing	17,400	19,650	19,000	14,000
End connection rivets:				
in web, bearing	15,200	16,900	16,500	14,000
to chord (field), shear	5,260	5,900	5,750	6,100
Lower Deck R. R. Stringers.				
Flange (incl. I of web)	9,920	10,060	11,170	10,000
Web shear (net sect.)	4,380	4,670	4,920	7,000
Fl. riv., shear	5,750	6,020	6,610	7,000
Fl. riv., bearing	10,490	11,000	12,050	14,000
Lower Deck Highway Stringers.	Load Provided by Specifications.			
Flange		12,750		15,000
Lower Deck Highway Cross Beams.				
Flange		14,800		15,000
Lower Deck R. R. Floorbeams.	14,250 lbs. Uniform.	14,250 lbs. Uniform + C.		
Flange (incl. I of web)	9,900	11,440		10,000
Web shear (net. sect.)	4,400	6,775		7,000
Fl. riv., shear	3,400	5,270		7,000
Fl. riv., bearing	10,800	16,600		14,000
End connection rivets:				
in web, bearing	11,200	17,300		14,000
to chord (field), shear	4,700	7,100		6,100
Lower Deck Highway Floorbeams.				
Flange (incl. I of web)	12,900	.....		15,000
Web shear (net sect.)	4,825	.....		10,000
Fl. riv., shear	3,750	.....		10,000
Fl. riv., bearing	11,800	.....		20,000
End connection rivets:				
in web, bearing	12,300	.....		20,000
to chord (field), shear	5,100	.....		8,700

LATERAL SYSTEM.—I find that in all cases the actual unit-stresses are within the limits specified.

Conclusions.

The foundations of the main towers are good and sufficient and appear to have been constructed in a first-class manner, and in accordance with the specifications.

The foundation of the Brooklyn anchorage is good and sufficient and appears to have been constructed in a first-class manner and in accordance with the specifications.

The foundation of the Manhattan anchorage could have been improved by driving inclined piles in the foundation, but since careful observations of its behavior do not develop any appreciable movement during the last sixty days, I consider this foundation as safe and sufficient.

The masonry of the towers and anchorages has been constructed in a first-class manner and to all appearances in accordance with the plans and specifications.

The pressures and internal stresses in the masonry are within the limits of good practice.

The inspection in the mills, foundries and shops has been thoroughly and conscientiously performed, the material complies in all respects with the requirements of the specifications and is of excellent quality throughout. The shop work is first-class in every respect.

The towers have been constructed and the cables with their anchorages installed in a workmanlike and accurate manner and in strict accordance with the specifications.

The stiffening trusses have been accurately erected, the joints have been carefully riveted up with due regard to difficulties attached to driving nickel-steel rivets.

The floor has been designed to carry safely the specified loads. Considering that the unit-stresses allowed by the specifications are very conservative and could safely be increased, the floor may be said to have a margin of strength for a limited future increase in the weight of cars.

As shown by quite recent experiments the splices in the stiffening trusses which are subject to reversal of stress have not, as a rule, a sufficient number of rivets to prevent the initial slip of plates. This, however, does not affect the safety of the structure in the least. The worst

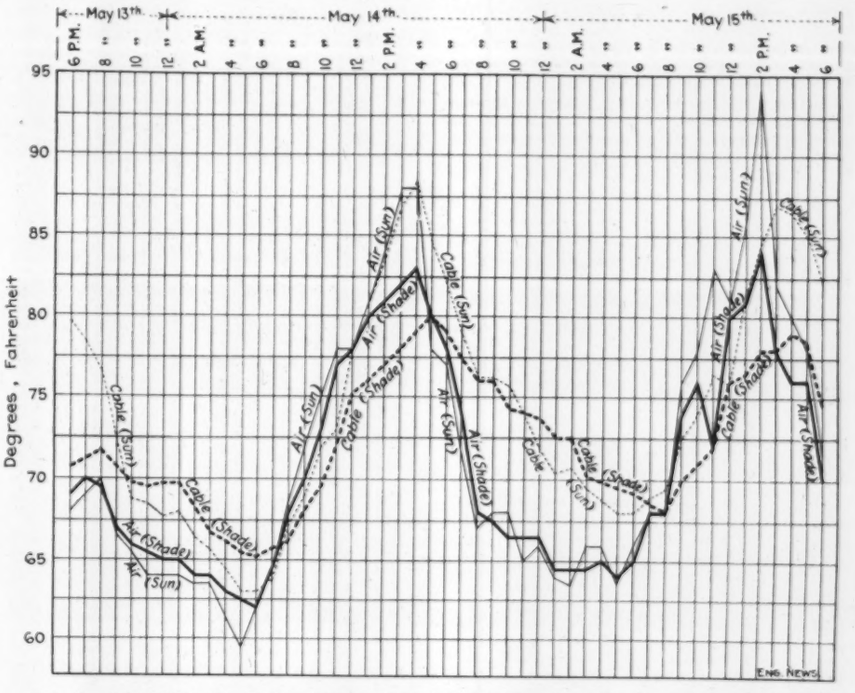


FIG. 4. COMPARISON OF TEMPERATURES OF CABLE AND AIR, MANHATTAN BRIDGE.

Heavy full line—Temperature of air in shade.
Light full line—Temperature of air in sun.
Heavy broken line—Temperature of cable in shade.
Light broken line—Temperature of cable in sun.

that could happen is that rivets in some of these splices would become loose and after a period of years would have to be replaced by either new rivets or tight-fitting bolts. There are enough rivets in these splices to make them safe against rupture under all conditions of loading. The number of rivets in these splices is in accordance with the specifications.

The structure as a whole has been carefully designed, and when completed will be amply strong to carry the heaviest traffic which may be placed upon it in the near future, as well as any reasonable additional increase in the weight of properly regulated traffic it may be called upon to carry for many years to come.

Respectfully submitted,

Ralph Modjeski.

Chicago, Ill., Sept. 16, 1909.

Appendix A.—Extract from Specifications for Superstructure.

LIVE-LOADS.

119. The bridge is proportioned to carry, in addition to its own weight and that of the floor, a live-load either uniform or concentrated or both, as specified below, placed so as to give the greatest stress in each part of the structure.

120. For the cables, trusses and towers:

(A) A load of 8,000 lbs. per lin. ft. of bridge as "regular," or (B) 16,000 lbs. per lin. ft. of bridge as "congested" traffic.

121. For the hangers, floorbeams and floor system:

(C) On all tracks a load of 52 tons on 4 axles, 6 ft. plus 10 ft. plus 6 ft. apart (the motor ends of two motor cars of the Interborough Rapid Transit Co.) (D) On any part of the roadway a load of 24 tons on 2 axles 10 ft. apart and 5 ft. gage (assumed to occupy a width of 12 ft. and a length of 30 ft.), and upon the remaining portion of the floor a load of 100 lbs. per sq. ft. (E) On the footwalks a load of 100 lbs. per sq. ft.

WIND PRESSURE.

122. The wind pressure is assumed as a moving load acting in either direction horizontally with 2,000 lbs. per lin. ft., but due allowance is made by taking the lateral deflection into account.

UNIT-STRESSES USED.

123. All steel work shall be so proportioned that the maximum stresses shall not cause greater unit-stresses than the following [see adjoining table.—Ed.].

In field-driven carbon-steel rivets, 15% shall be added to the number of rivets required by the foregoing permissible stresses.

Appendix B.—Derivation of Formulas Used in the Calculation of Stresses in the Stiffening Trusses.

(By Prof. F. E. Turneaure.)

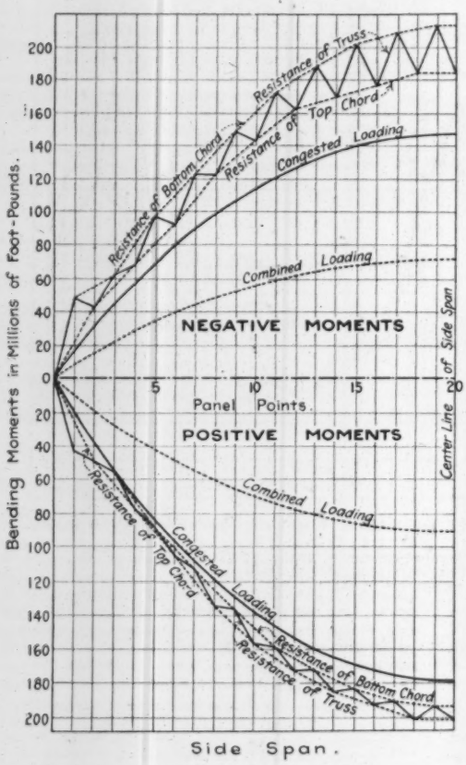
In a structure of the proportions of the Manhattan bridge, it is necessary to employ a relatively accurate method of calculation in order that the accuracy of the results may be within reasonable limits. The deflections of the structure under congested load amount to several feet and should be taken account of in the calculations. For these conditions the method given in general outline by Prof. J. Melan, in "Handbuch der

TABLE OF UNIT STRESSES.

	Lbs. per sq. in. For dead-load, temperature and regular live-load or for dead-load temperature and wind.	For dead-load, temperature and congested live-load or for dead-load, regular live-load temperature and wind.
(a) For Wire:		
Main cables	60,000	73,000
Suspenders	30,000	.....
(b) For Nickel-steel:		
Tension in stiffening trusses	.....	40,000
Compression in stiffening strusses	.....	40,000—150 l/r
Shear on rivets in stiffening trusses, field	.....	20,000
Bearing on rivets in stiffening trusses, field	.....	35,000
(c) For Structural Steel in Towers:		
Tension	20,000	25,000*
Compression	22,000—90 l/r	27,000—100 l/r*
Shear on shop rivets and bolts	13,000	16,000
Bearing on shop rivets and bolts	25,000	30,000
(d) For Structural Steel in Stiffening Trusses:		
Tension	20,000	24,000
Compression	20,000—90 l/r	24,000—100 l/r
Shear on shop rivets	13,000	.....
Bearing on shop rivets	25,000	.....
(e) For Structural Steel in Floor System of Roadway and Footways:		
Tension chords	15,000	.....
Shear on shop rivets, bolts and web-plate net section	10,000	.....
Bearing on shop rivets and bolts	20,000	.....
(f) For Structural Steel in Floor System for Railroad & Trolley Tracks:		
Tension chords	10,000	.....
Shear on shop rivets, bolts and web-plate net section	7,000	.....
Bearing on shop rivets and bolts	14,000	.....
(g) For Structural Steel in Anchorages:		
Tension in eyebars	16,000	20,000
Bearing on diameter of pins	22,000	.....
Bending on outer fiber of pins	22,000	.....
Shear on pins	12,000	.....

*Including secondary stresses.

Ingenieurwissenschaften," Third Edition, 1906, and there called the "Genauere Theorie," is well suited and convenient of application. In certain particulars it is not absolutely exact, but the errors involved are of no practical consequence. This method is the same as that which has been fully developed by Mr. Moisseiff and used by him in his calculations; but in the work of recalculation, the formulas for cable stresses have been developed



somewhat further and brought into a form more convenient of application. The derivation of the principal formulas will be briefly given.

ASSUMPTIONS.—(1) The initial curve of the cable is parabolic; for the end span the vertex of the parabola is at the span center and the tangent at this point is inclined but the axis is vertical.

(2) The entire dead-load is carried by the cable as a uniform load and causes no stress in the truss; the truss is stressed by changes of temperature from the mean, and by live-load.

FORMULAS FOR DEFLECTION, BENDING MOMENT AND SHEAR.—Consider first the main span only. Let

H_t = horizontal component of cable stress from dead-load only and mean temperature;

H = additional horizontal component of cable stress due to any cause, such as live-load, or temperature change, or loads on side spans;

η = deflection of truss and cable at any point A from normal position, due to H and any given live-load (the stretch of the hanger is neglected);

p = live-load per unit length on a part or all of the truss;

M_0 = bending moment at any point in the truss due to the given live-load, assuming the truss to be a simply supported beam;

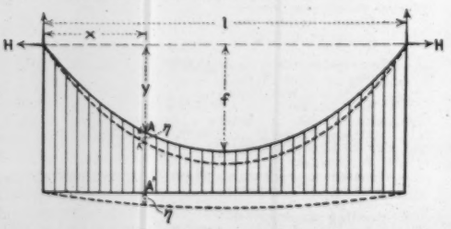
M = actual bending moment in the truss at any point due to the assumed conditions;

S = shear at any point;

s_0 = dead-load per unit length, = load on cable (including its own weight);

s_1 = total load on cable per unit length, after advent of live-load or temperature change;

I = moment of inertia of the truss.



Under all conditions the shape of the cable constitutes an equilibrium polygon for the hanger loads, and if the horizontal component $H + H_t$ of its stress is known,

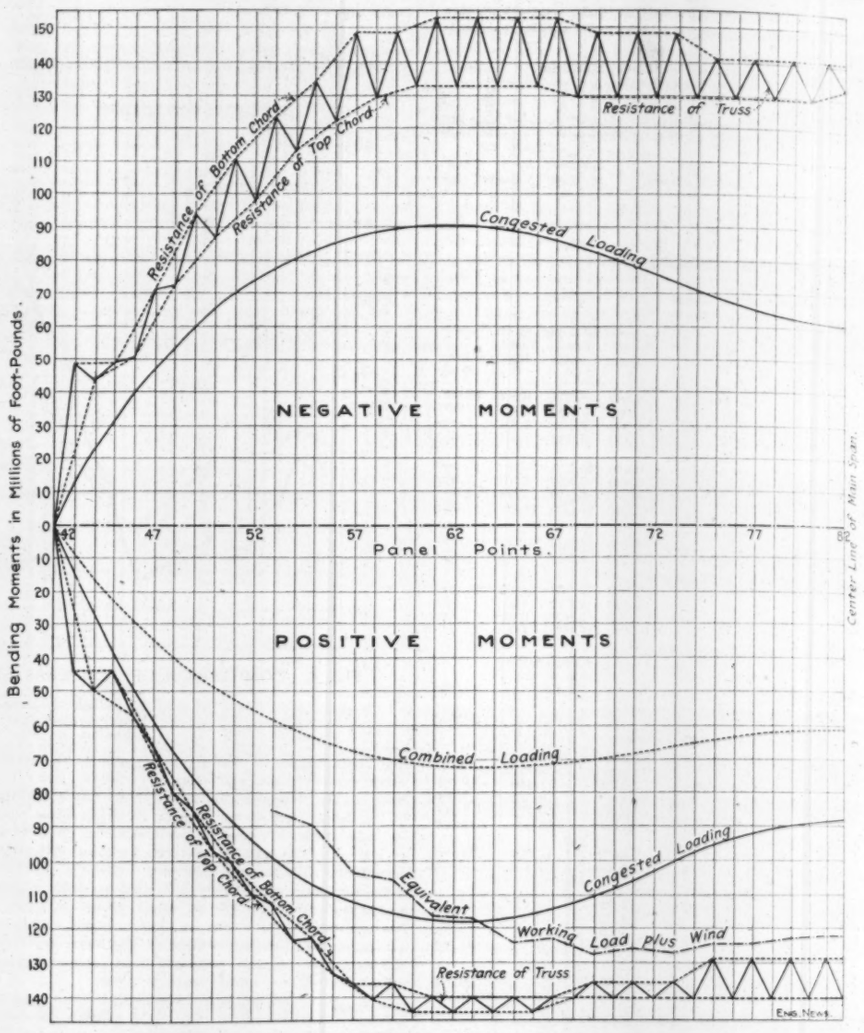


FIG. 5. MAXIMUM MOMENTS IN STIFFENING TRUSSES.

LIVE-LOAD—
Congested: 16,000 lbs. per lin. ft. of bridge either continuous or partial, placed to give maximum effect.
Combined: 8,000 lbs. per lin. ft. of bridge continuous, and additional partial load of 8,000 lbs. per lin. ft. of bridge placed to give maximum effect.
Working Load: 8,000 lbs. per lin. ft. of bridge either continuous or partial, placed to give maximum effect.
Wind: 2,000 lbs. per lin. ft. of bridge.

then the moment of the hanger stresses on the truss at point A is equal to $(H + H_t) \times (y + \eta)$. But $H_t y$ just balances the dead load, so that the moment tending to balance the effect of the live-load (or temperature change) is only $(H + H_t)\ \eta + Hy$. Hence the moment in the truss due to this live-load (or temperature effect) is

$$M = M_0 - (H + H_t)\ \eta - Hy \quad \ldots\ldots\ldots\ldots (1)$$

Consider any portion of the truss along which p and I may be assumed as constant, and suppose the left end of this section is at a distance a from the origin. The value of M_0 at any point in this section can be written

$$M_0 = M_1 + Q\ (x - a) - \tfrac{1}{2}\ p\ (x - a)^2 \ldots\ldots (2)$$

in which M_1 is the bending moment and Q is the shear at the left end of this section. Also, for the initial parabola, we have [measuring x from one end of the span],

$$y = \frac{4f}{l^2}\, x\,(l - x).$$

Hence, from (1) and (2) we derive

$$M = M_1 + Q\,(x-a) - \frac{p\,(x-a)^2}{2} - (H + H_t)\,\eta - H\left[\frac{4f}{l^2}\,x\,(l-x)\right] \ldots\ldots (3)$$

With respect to the truss the general relation of deflection to bending moment is

$$E\,I\,\frac{d^2\eta}{dx^2} = -M$$

Substituting in (3) and placing $\frac{H + H_t}{EI} = c^2$ we have for the differential equation of the elastic curve of the truss,

$$\frac{d^2\eta}{dx^2} = c^2\eta - \frac{c^2}{H + H_t}\left[M_1 + Q(x-a) - \frac{p(x-a)^2}{2}\right] + \frac{Hc^2}{H + H_t}\left[\frac{4f}{l^2}\,x\,(l-x)\right] \quad \ldots\ldots (4)$$

Integrating this, and using again the term M_0 for brevity, we have, finally, for the deflection:

$$\eta = \frac{H}{H + H_t}\left[C_1\,e^{cx} + C_2\,e^{-cx} + \frac{M_0}{H} - \frac{p}{Hc^2} + \frac{8f}{c^2 l^2} - \frac{4fx}{l^2}\,(l-x)\right] \quad \ldots\ldots (5)$$

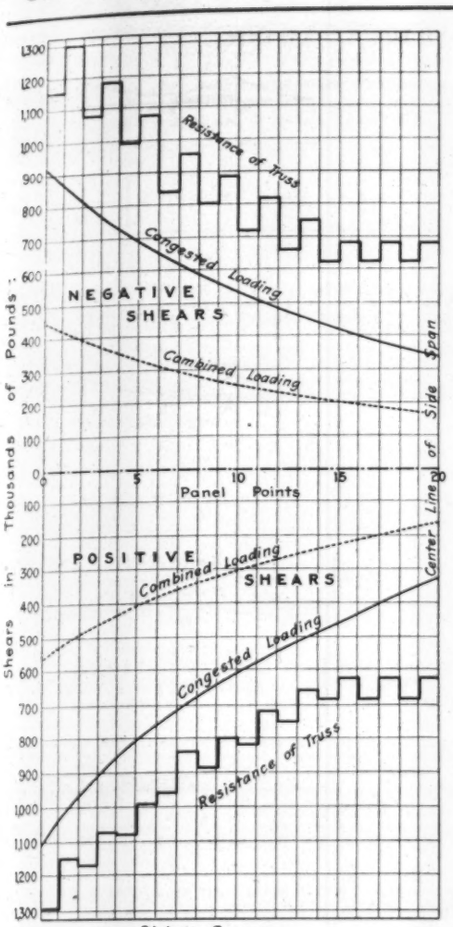
Then from (1), the bending moment at any point is

$$M = -H\left[C_1\,e^{cx} + C_2\,e^{-cx} + \frac{1}{c^2}\left(\frac{8f}{l^2} - \frac{p}{H}\right)\right] \quad \ldots (6)$$

and by differentiation, the shear is

$$S = \frac{dM}{dx} = -Hc\,[C_1\,e^{cx} - C_2\,e^{-cx}] \quad \ldots (9)$$

The quantities C_1 and C_2 are constants, to be determined by the conditions of the case. For each different value of p or of I there is a corresponding set of values of C_1 and C_2. For a uniform load throughout, and constant I, they are obtained from the two conditions that for $x = 0$ and $x = l$, $M = 0$. For a change in p or I the truss must be divided into sections in each of which p and I may be taken as constant. The addi-



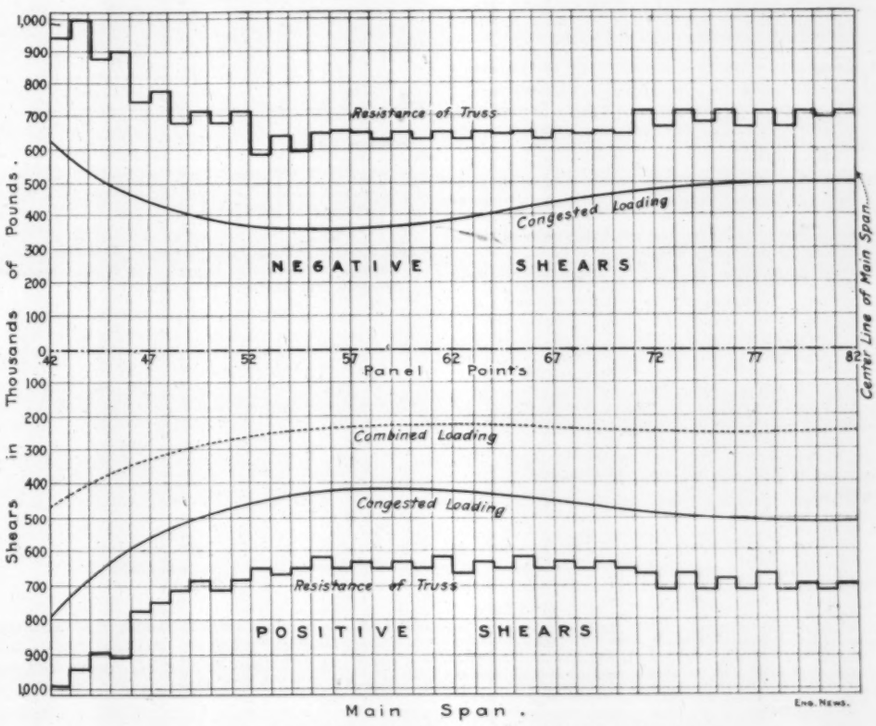


FIG. 6. MAXIMUM SHEARS IN STIFFENING TRUSSES.
(For Congested and Combined Loading as noted under Fig. 5.)

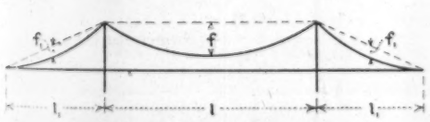
tional equations for determining the various sets of values for C_1 and C_2 are found by equating the value of M at the end of each section with that at the beginning of the next, and by a similar treatment of the shears.

Formulas (5), (6) and (7) onable the deflections, moments and shears to be calculated at any point in the main span for any given value of cable stress H and of load p on this span.

The formulas are also applicable to side spans by using the span length l_1, and versed sine f_1, for these spans, in place of the value l and f in the given equations.

The cable stress H may be caused by a load on either main or side span or by temperature change. It remains to derive an expression for this cable stress H due to any cause.

FORMULA FOR H.—In deriving an expression for H the entire cable from anchorage to anchorage must be



considered. Imagine the hangers to be cut just below the cable and their stresses replaced by external forces. The total load per foot acting on the cable after advent of live-load or temperature change will be equal to s_1. The application of this live-load or temperature change will cause the cable to stretch and will also cause vertical displacements along the cable, some downwards and some upwards. The total work performed in this vertical movement must be equal to the total work done in stretching the cable.

Work in Cable due to Stress.—Let F = constant cross-section of cable and ds = increment of length. The stress at any point in the cable due to H is $H\frac{ds}{dx}$, and the stretch of an element ds is $\frac{H}{F.E}\frac{ds}{dx}ds$. The average total stress at the same point is

$$(H_t + \tfrac{1}{2}H)\frac{ds}{dx}$$

and hence the work done on this element is

$$\frac{H\,(H_t + \tfrac{1}{2}H)}{F.\,E}\cdot\frac{ds^3}{dx^2}.$$

The total work on the cable may then be written

$$\frac{H(H_t + \tfrac{1}{2}H)}{F.E}\cdot\int\frac{ds^3}{dx^2}.$$

Work in Cable due to Temperature Change.—Let w = coefficient of expansion and t = change of temperature. The stretch of any element ds is $wtds$, and the average stress is

$$(H_t + \tfrac{1}{2}H)\frac{ds}{dx};$$

hence the work done is equal to

$$(H_t + \tfrac{1}{2}H)\,wt\int\frac{ds^2}{dx}.$$

Work Done by Vertical Displacement.—The load per unit length is s_1 and the movement is η; hence the work done is

$$\int s_1\,\eta\,dx$$

The dead load is uniformly distributed on the cable, and for the purpose of calculating

$$\int s_1\,\eta dx.$$

the additional load may also be assumed as uniformly distributed. The average value of s_1 is then approximately equal to $\frac{8f}{l^2}(Ht + \tfrac{1}{2}H)$. The work is then given by the expression

$$\frac{8f}{l^2}(H_t + \tfrac{1}{2}H)\int\eta dx.$$

A similar expression gives the work for the side spans.

Formula for H.—Equating the work in the cable with that of vertical displacement we have

$$\frac{8f}{l^2}(H_t + \tfrac{1}{2}H)\left[\int\eta dx + \int\eta_1 dx\right] = \frac{H(H_t + \tfrac{1}{2}H)}{F.E}\int\frac{ds^3}{dx^2} + (H_t + \tfrac{1}{2}H)\,wt\int\frac{ds^2}{dx} \quad \ldots\ldots\ldots(8)$$

in which the subscript "1" refers to side spans.

Substituting the value of η from equation (5), integrating terms $\frac{4fx}{l^2}(l - x)dx$ and solving for H, we derive the general expression,

$$H = \frac{\displaystyle\int_0^l\left(M_o - \frac{p}{c^2}\right)dx + \begin{bmatrix}\text{terms}\\ \text{for side}\\ \text{spans}\end{bmatrix} - \frac{l^2 wt\,H_t}{8f}\int\frac{ds^2}{dx}}{\displaystyle -\int_0^l(C_1 e^{cx} + C_2 e^{-cx})\,dx - \frac{8f}{c^2 l} + \frac{8}{3}f\,l + \begin{bmatrix}\text{terms}\\ \text{for side}\\ \text{spans}\end{bmatrix} + \frac{l^2 wt}{8f}\int\frac{ds^2}{dx} + \frac{H + H_t}{FE}\,\frac{l^2}{8f}\int\frac{ds^3}{dx^2}} \quad \ldots\ldots(9)$$

The brackets indicate that terms for each side span are to be written out exactly similar to the preceding terms for the main span. If there are no loads on any one span then the values of M_o and p for that span are zero. It is to be noted that in equation (9) the quantities C_1 and C_2, and also c, contain the quantity H so that the value of H can be determined only by successive approximations. However, for any particular form of loading, the constants C_1 and C_2 can be expressed in detail, and some of the terms containing H transferred to the first member of the equation and a more convenient expression for H derived. One result of such transformation is to make the denominator of the expression for H identically the same for all conditions of loading. Its value can then be calculated for all possible values of H and tabulated, thus greatly facilitating the calculations. Formulas for H for various cases are given in the tables of formulas which follow.

Formulas for Various Cases.—The formulas for H used in the calculations for various cases of loading and the values of the constants C_1 and C_2 are as follows: [See tabulation on pp. 408-09.—Ed.]

The full expression for the denominator of the various formulas is, calling

$$\int\frac{ds^3}{dx} = L_3 \text{ and } \int\frac{ds^2}{dx} = L_1,$$

$$D = \frac{16f\,(e^{cl} - 1)}{c^3 l^2(e^{cl} + 1)} + \frac{2}{3}fl - \frac{8f}{c^2 l} + \frac{32f_1(e^{c_1 l_1} - 1)}{c_1^3 l_1^2(e^{c_1 l_1} + 1)} + \frac{4}{3}f_1 l_1 - \frac{16f_1}{c_1^2 l_1} + \frac{l^2 c^2 I L_3}{8fFe} \pm \frac{l^2 wt L_1}{8f}$$

Values of Constants.—The following constants were used in the calculations:

Main Span:		Side Span:	
l =	1,446.7 ft.	l_1 =	713.5 ft.
f =	145.3 ft.	f_1 =	37.2 ft.
I =	43,900 sq. ins. × sq. ft.	I =	50,860 sq. ins. × sq. ft.

E = 29,000,000; w = .0000066; t = 55°; Ht = 10,480,000 lbs.; L_t = 3,324 ft.; L_s = 3,452 ft.

Appendix C.—Method Used in the Calculation of Stresses in the Tower and Cable.

The maximum fiber stress in a column of this type, fixed at one end and saddles rigidly attached at the other, occurs during the greatest horizontal displacement of its top, under which condition it resists a vertical and horizontal cable force; it is produced by loading the main and far side spans at the highest temperature.

The maximum stress in the cable occurs when all spans are loaded at the lowest temperature.

In the diagram below, let α = angle between main

span cable curve under dead-load and a horizontal line connecting tangent points of saddles.

α_1 = angle between side span cable curve under dead-load and an inclined line connecting tangent points of saddles.

β = the constant angle between the inclined line and a horizontal.

The change in the tangents of α and α_1 caused by the load p is $\frac{d\eta}{dx}$ and $\frac{d\eta_1}{dx}$, and after correcting for this change the vertical cable force becomes,

$$V = [H + Ht]\ [\tan \alpha + \tan (\alpha_1 + \beta)\ ]$$

The horizontal displacement Y of the top of the tower is due to the up-bending of the unloaded side span or decrease in f_1, the elongation of the unloaded side span cable from stress

$$\left(\frac{H}{FE}\int\frac{ds^3}{dx^2}\right)$$

and from temperature

$$\left(wt\int\frac{ds^2}{dx}\right)$$

and the resistance of the tower to bending. Calling the length of side span cable L, the change in l_1 from a decrease in f_1 and from

$$wt\int\frac{ds^2}{dx}$$

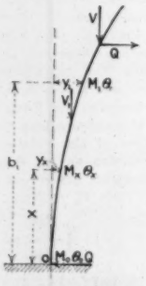
$$\frac{H}{FE}\int\frac{ds^3}{dx^2}$$

is given by the partial differentials

$$\frac{\delta L}{\delta l_1} \text{ and } \frac{\delta L}{\delta f_1} \text{ of}$$

$$L = \frac{4f_1 - a}{16f_1}\sqrt{l_1^2 + (4f_1 - a)^2} + \frac{4f_1 + a}{16f_1}\sqrt{l_1^2 + (4f_1 + a)^2} + \frac{l_1^2}{16f_1} + \log_e\frac{4f_1 + a + \sqrt{l_1^2 + (4f_1 + a)^2}}{-4f_1 + a + \sqrt{l_1^2 + (4f_1 - a)^2}}$$

from which the horizontal cable force Q is determined, as follows:



Let the curved line represent the axis of the deflected tower. Let

y = the deflection at any point from the tangent OC at the fixed end.

θ = the angle between the tangent at any point and the line OC

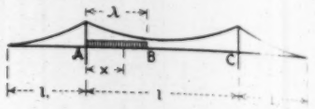
M = the bending moment at any point from V, Q and V_1 (truss reaction).

The relation between the deflection and bending moment at any point x is

$$M_x = EI\frac{d^2y}{dx^2} = M_o - Qx - (V + V_1)y$$

FORMULAS FOR H AND THEIR CONSTANTS.

CASE I.—Center Span Partially Loaded, Side Spans Unloaded, Temperature highest. Maximum Positive Moments and Shears, Center Span.

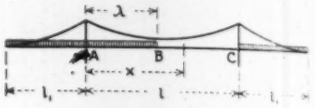


$$H = \frac{p\lambda\left[\frac{\lambda}{12}\left(3l - 2\lambda\right) - \frac{1}{c^2}\right] - \frac{p}{c^3(e^{cl} - e^{-cl})}\left[2 - e^{-cl} - e^{cl} - e^{c\lambda} - e^{-c\lambda} + e^{c(l-\lambda)} + e^{-c(l-\lambda)}\right] - \frac{I^2 L_t}{8f}wtH_t}{D}$$

Section A to B:

$$C_1 = \frac{1}{e^{cl} - e^{-cl}}\left[\frac{p}{2Hc^2}\left(e^{c(l-\lambda)} + e^{-c(l-\lambda)} - 2e^{-cl}\right) - \frac{8f}{c^2l^2}\left(1 - e^{-cl}\right)\right] \qquad C_2 = -C_1 + \frac{1}{c^2}\left(\frac{p}{H} - \frac{8f}{l^2}\right)$$

CASE II.—Center Span Partially Loaded, Side Spans Fully Loaded, Temperature Lowest. Maximum Negative Moments and Shears, Center Span.

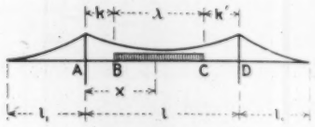


$$H = \frac{p\lambda\left[\frac{\lambda}{12}\left(3l - 2\lambda\right) - \frac{1}{c^2}\right] - \frac{P}{c^3(e^{cl} - e^{-cl})}\left[2 - e^{-cl} - e^{cl} - e^{c\lambda} - e^{-c\lambda} + e^{c(l-\lambda)} + e^{-c(l-\lambda)}\right] + 2p\,l_1\left[\frac{l_1^2}{12} - \frac{1}{c_1^2}\right] + \frac{4p\,(e^{c_1l_1} - 1)}{C_1^3(e^{c_1l_1} + 1)} + \frac{I^2 L_t wt H_t}{8f}}{D}$$

Section B to C:

$$C_1 = \frac{e^{-cl}}{e^{cl} - e^{-cl}}\left[\frac{p}{2Hc^2}\left(e^{c\lambda} + e^{-c\lambda} - 2\right) + \frac{8f}{c^2l^2}\left(1 - e^{-cl}\right)\right] \qquad C_2 = -C_1\,e^{2cl} - e^{cl}\frac{8f}{c^2l^2}$$

CASE III.—Center Span Partially Loaded, Side Spans Unloaded, Temperature Highest. Maximum Positive Moments and Deflections Near Center. Center Span and Max. Pos. Shears Near End.



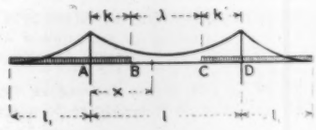
$$H = \frac{p\lambda\left[\frac{k(l-k) + k^1(l-k^1)}{4} + \frac{\lambda^2}{12} - \frac{1}{c^2}\right] - \frac{p}{c^3(e^{cl} - e^{-cl})}\left[e^{ck'} + e^{-ck'} - e^{c(l-k)} - e^{-c(l-k)} - e^{ck} + e^{-ck} - e^{c(l-k')} - e^{-c(l-k')}\right] - \frac{I^2 L}{8f}wtH_t}{D}$$

Section B to C:

$$C_1 = \frac{1}{e^{cl} - e^{-cl}}\left[\frac{p}{2Hc^2}\left(e^{ck'} + e^{-ck'} - e^{-c(l-k)} - e^{-c(l+k)}\right) - \frac{8f}{c^2l^2(1 + e^{cl})}\right]$$

$$C_2 = -C_1 + \frac{p}{2Hc^2}\left(e^{ck} + e^{-ck}\right) - \frac{8f}{c^2l^2}$$

CASE IV.—Center Span Partially Loaded, Side Spans Fully Loaded, Temperature Lowest. Negrtive Moment Near Center, Negative Shear Near Ends, Center Span.



$$H = \frac{pl\left[\frac{l^2}{12} - \frac{1}{c^2}\right] + 2p\,l_1\left[\frac{l_1^2}{12} - \frac{1}{c_1^2}\right] + \frac{2p}{c^3}\frac{(e^{cl} - 1)}{(e^{cl} + 1)} + \frac{4p}{c_1^3}\frac{(e^{c_1l_1} - 1)}{(e^{c_1l_1} + 1)} - [\text{Numerator CASE III}]}{D}$$

$$C_1 = \frac{1}{e^{cl} - e^{-cl}}\left[\frac{p}{2Hc^2}\left(e^{-c(l-k)} + e^{-c(l+k)} - e^{ck'} - e^{-ck'}\right) + \frac{1}{c^2}\left(\frac{p}{H} - \frac{8f}{l^2}\right)\left(1 - e^{-cl}\right)\right]$$

$$C_2 = -C_1 - \frac{p}{2Hc_2}\left(e^{ck} + e^{-ck}\right) + \frac{1}{c^2}\left(\frac{p}{H} - \frac{8f}{l^2}\right)$$

The term $(V + V_1)y$ is small in this case and may be neglected, consequently

$$y = \frac{1}{EI}\left(\frac{M_o x^2}{2} - \frac{Qx^3}{6}\right) + x\tan\theta_o + c$$

in which $c = 0$ for $y = 0$.

The value of Q is found by successive approximations, so that $\Sigma y = Y$. With the external forces V, Q and V_1 determined, the fiber stresses at the various sections readily follow.

The maximum cable stress = $(H + H_\theta)$ sec. α or $(H + H_\theta)$ sec. $(\beta + \alpha_1)$; α and α_1 being corrected for the change produced by p.

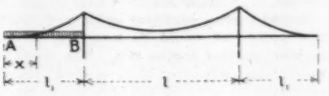
In the calculations the resistance of the tower to bending was not considered, this being an approximation on the safe side.

Appendix D.—Method Used in the Calculation of Stresses in the Lower Floorbeams and Lateral System.

FLOORBEAMS.—The maximum flange stress in the floorbeams occurs during the greatest difference in deflection of the cables and is caused by loading the sidewalk and tracks on one side and the roadway. The beams are continuous and the elevation of the supports or deflection of the cables depends on the loads transferred to them by the stiffness of the beams.

FORMULAS FOR H AND THEIR CONSTANTS (Continued).

CASE V.—One Side Span Fully Loaded, Other Unloaded, Center Span Unloaded, Temperature Highest. Maximum Positive Moments and Deflection, Loaded Side Span.

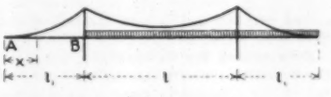


$$H = \frac{p\,l_1\left(\frac{l_1^2}{12} - \frac{1}{c_1^2}\right) + \frac{2\,p}{c_1^3}\frac{(e^{c_1 l_1} - 1)}{(e^{c_1 l_1} + 1)} - \frac{l^2 L_t}{8 f} w\,t\,H_t}{D}$$

Section A to B:

$$C_1 = \frac{1}{1 + e^{c_1 l_1}}\left(\frac{p}{H c_1^2} - \frac{8 f_1}{c_1^2 l_1^2}\right) \qquad C_2 = C_1 e^{c_1 l_1}$$

CASE VI.—Center Span Fully Loaded, One Side Span Loaded, Other Unloaded, Temperature Lowest. Maximum Negative Moments and Negative Shears Near End, Unloaded Side Span.

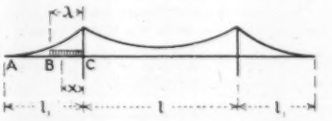


$$H = \frac{p\,l\left[\frac{l^2}{12} - \frac{1}{c^2}\right] + p\,l_1\left[\frac{l_1^2}{12} - \frac{1}{c_1^2}\right] + \frac{2\,p}{c^3}\frac{(e^{cl} - 1)}{(e^{cl} + 1)} + \frac{2p}{c_1^3}\frac{(e^{c_1 l_1} - 1)}{(e^{c_1 l_1} + 1)} + \frac{l^2 L_t}{8 f} w\,t\,H_t}{D}$$

Section A to B:

$$C_1 = -\frac{1}{1 + e^{c_1 l_1}} \cdot \frac{8 f_1}{c_1^2 l_1^2} \qquad C_2 = C_1 e^{c_1 l_1}$$

CASE VII.—One Side Span Partially Loaded, Other Spans Unloaded, Temperature Highest. Positive Shears, Loaded Side Span.



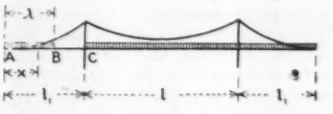
$$H = \frac{p\lambda\left[\frac{\lambda}{12}\left(3 l_1 - 2\lambda\right) - \frac{1}{c_1^2}\right] - \frac{p}{c_1^3\left(e^{c_1 l_1} - e^{-c_1 l_1}\right)}\left[2 - e^{-c_1 l_1} - e^{c_1 l_1} - e^{c_1\lambda} - e^{-c_1\lambda} + e^{c_1(l_1 - \lambda)} + e^{-c_1(l_1 - \lambda)}\right] - \frac{l^2 L_t}{8 f} w t H_t}{D}$$

Section B to C:

$$C_1 = \frac{1}{e^{c_1 l_1} - e^{-c_1 l_1}}\left[\frac{p}{2 H c_1^2}\left(e^{c_1(l_1 - \lambda)} + e^{-c_1(l_1 - \lambda)} - 2 e^{-c_1 l_1}\right) - \frac{8 f_1}{c_1^2 l_1^2}\left(1 - e^{-c_1 l_1}\right)\right]$$

$$C_2 = -C_1 + \frac{1}{c_1^2}\left(\frac{p}{H} + \frac{8 f_1}{l_1^2}\right)$$

CASE VIII.—One Side Span Partially, other Fully Loaded, Center Span Fully Loaded, Temperature Lowest. Negative Shears, Partially Loaded Side Span.



$$H = \frac{p\,l\left[\frac{l^2}{12} - \frac{1}{c^2}\right] + p\,l_1\left[\frac{l_1^2}{12} - \frac{1}{c_1^2}\right] + \frac{2\,p}{c^3}\frac{(e^{cl} - 1)}{(e^{cl} + 1)} + \frac{2\,p}{c_1^3}\frac{(e^{c_1 l_1} - 1)}{(e^{c_1 l_1} + 1)} + p\lambda\left[\frac{\lambda}{12}(3 l_1 - 2\lambda) - \frac{1}{c_1^2}\right]}{} - \frac{p}{c_1^3\left(e^{c_1 l_1} - e^{-c_1 l_1}\right)}\left[2 - e^{c_1 l_1} - e^{-c_1 l_1} - e^{c_1\lambda} - e^{-c_1\lambda} + e^{c_1(l_1 - \lambda)} + e^{-c_1(l_1 - \lambda)}\right] + \frac{l^2 L_t}{8 f} w\,t\,H_t}{D}$$

Section A to B:

$$C_1 = \frac{1}{e^{c_1 l_1} - e^{-c_1 l_1}}\left[\frac{p}{2 H c_1^2}\left(e^{c_1(l_1 - \lambda)} + e^{-c_1(l_1 - \lambda)} - 2 e^{-c_1 l_1}\right) - \frac{8 f_1}{c_1^2 l^2}\left(1 - e^{-c_1 l_1}\right)\right]$$

$$C_2 = -c_1 + \frac{1}{c_1^2}\left(\frac{p}{H} - \frac{8 f_1}{l_1^2}\right)$$

Two equations

At center, $\eta = .00266\,(p - .000027 p^2)$ and

At quarters, $\eta = .00195\,(p - .000017\,p^2)$

giving the deflection of the cable at the center and quarter-point of the main span for varying intensities of load were developed and by successive approximations the reactions and elevations at the four supports determined by substituting these in the equation for a continuous beam.

LATERALS.—Stresses in the lateral system were computed for a fixed and a moving load, the intensity of wind being determined from the specifications as 33⅓ lbs. per sq. ft. on exposed surfaces of suspended structure and trains. If

W_c = weight per lineal foot, of cable.
W_t = weight per lineal foot, of truss.
W_r = weight per lineal foot, of trains.
ϕ = the angle of deflection at any point,

the side deflections of the cable, truss and lateral system are proportional to their distance from the center of rotation (a line connecting tangent points of saddle) and induce reactive forces: $W_c \tan \phi$, $W_t \tan \phi$ and $W_r \tan \phi$, which were assumed to vary as ordinates of a parabola and resist corresponding amounts of wind pressure, the remainder being carried by the lateral system as a simple truss.

The center deflection of the side span is 3¼ ins. and the reactive forces or components due to weight are small; consequently these were neglected in computing this lateral system.

MATERIAL FOR HIGHWAY IMPROVEMENT is carried on the railways of Virginia at freight rates which represent actual cost, according to the Baltimore "Sun."

Recent State Highway Construction in Massachusetts.*

By AUSTIN B. FLETCHER.†

Macadam's road is a thing of the past. In fact, the road of the kind built by the Scotchman, John Loudon Macadam, and named in his honor, has been obsolete in this country for so long a time that the road makers of the present day have almost forgotten what it was like. Except that it was made of fairly small broken stones it bore little resemblance to the carefully built broken stone road usually adopted for State highway constructions of the present day.

Macadam knew nothing of machine-broken stone. He did not dream that a broken stone roadway could be made as smooth as a billiard table immediately on its completion by the use of steam road rollers.

The modern macadam roads, when made of a good quality of stone, such as can be obtained usually in Massachusetts, and under the average road traffic conditions, and when the automobile was not ubiquitous, were reasonably expected to wear at least ten years without resurfacing. These roads cost for the four to six-inch broken stone surfacings alone, not including any items like grading, draining, foundations, etc., from $2,500 to $6,500 per mile, 15 ft. in width. They are not cheap roads and their construction is not justified in rural localities unless the traffic requires such a type of construction, or unless cheaper methods are not available because of the lack of suitable material less costly than broken stone.

It would seem fairer to call such a road a "McClintock" road, since its development, to a very large extent was due to the efforts of William E. McClintock, a member of the Massachusetts Highway Commission, who retired from the Commission in 1908 after a faithful and able service of more than 15 years.

The Massachusetts Commission has been recently taking a census of the travel over the state roads to secure more accurate knowledge as to the relative importance of the different routes of travel under the changed traffic conditions, and to determine what proportion of the travel was in self-propelled vehicles. The count was taken for seven consecutive days, during the latter part of August, at 237 different stations, and the results deduced from the census are somewhat surprising in some particulars.

The census shows that the travel per day over all the roads where the records were taken was as follows:

Horse-drawn—		
Light	19,622	
Heavy	17,969	
All		37,591
Automobile—		
Runabouts	5,922	
Touring cars	21,387	
All		27,309
Total average daily traffic		64,900

The average traffic per station (237 stations) was as follows:

Horse-drawn—		
Light	83	
Heavy	76	
All		159
Automobile—		
Runabouts	25	
Touring cars	90	
All		115
Total traffic of all kinds per day, per station		274

These figures must be considered as applying only to the abnormal summer travel. Massachusetts roads and scenery appear to be attractive to automobilists from other states, and it is likely that the figures are somewhat enhanced by reason of that fact. It is expected that a similar census, which will be taken early in October, will measure the normal traffic more closely.

A rather ingenious method of getting at an approximation of the value of a road was devised several years ago by Mr. A. N. Johnson, State Highway Engineer of Illinois. In some of his calculations in Illinois he assumed that the value of a journey of any sort of a vehicle for one mile was one cent, which I believe was about one-third of the minimum price per mile which was being charged on the Maryland turnpikes, but he chose this ridiculously low figure so that his calculations would be beyond criticism.

It has occurred to me to apply this value of a mile journey idea to the Massachusetts traffic census figures to see whether the Massachusetts repair costs are justified on the one cent a mile basis.

Let us assume that the average traffic per station of 274 vehicles per day is too large by 25% when normal traffic conditions are under consideration; that the roads of Massachusetts are unprotected by Nature's snow and ice for 300 days each year; that every vehicle counted at every station averaged to go at least one mile; that the macadam road surfacings cost on the average $5,000 per mile, which is probably nearly correct, and that the State pays for the money used in building the roads 3½%

*From a paper read at the Good Roads Convention at Cleveland, O.

†Secretary, Massachusetts Highway Commission, Boston, Mass.

per annum. I disregard the facts that the counties pay back to the commonwealth 25% of the construction and maintenance costs and that the cities and towns pay back a portion of the maintenance costs, and that the automobilists are now paying a substantial amount each year toward the cost of maintenance.

With these assumptions, the people would pay in tolls on the Johnson basis: 300 × 205.5 × $0.01—approximately $615 per mile per year, and the Commopwealth, if it were in the turnpike business and paid no dividends, could use $615, less $175 interest charges, or $440 per year per mile for maintenance and administration. If the Commonwealth would appropriate that amount each year for each mile of state highway the Commission's work would be simplified.

The census shows that of the total summer traffic 42% was self-propelled. What proportion of this annual cost of maintaining the State roads is chargeable to the 42% of automobile traffic? In my opinion, the Commission's estimate made last spring, that motor vehicles cause at least 50% of the wear and tear, is conservative in the extreme. Unfortunately, there are no data accurate enough to settle the question conclusively.

The figures from the census do show beyond a question that the automobile is a serious factor to be reckoned with in all future road building and road maintenance, and no one now believes that the self-propelled vehicle will be a diminishing element in the future. The roads, therefore, must be rebuilt or resurfaced to provide for the changed conditions, and in all new constructions the conditions must be met.

So far as the treatment of existing macadam roads is concerned, the remedy seems to be in the application of protective coats or coverings of a bituminous nature. Generally speaking, the smoothest surface is highly desirable for the automobile, but the horse needs some degree of roughness of road surface to give him foothold when exerting his strength.

Taking these things into consideration, so long as there are many horses to be reckoned with, some material or combination of materials must be found which will not result in a too smooth and hard road surface. It is not my intention to enter into a discussion here of the relative merits of asphalts, asphaltic oils and tars, all of which are being used in making the protective coverings referred to. At the present time there are not enough data available to show which will give the best results economically in a term of years, and probably at least three more years of experimenting will be necessary to determine it. All of these materials seem to give good temporary results.

Before any of the bituminous materials are applied it is essential that the road surface be evened up and patched where necessary, rolled and swept clean of all dust. The bituminous materials in the Massachusetts experiments are then applied hot to the road surface by means of spraying machines or gravity distributors or by hand in quantities varying from one-fourth to three-fourths of a gallon to the square yard, and immediately covered evenly with sand, fine gravel or broken stone screenings. The surface is then rolled, and there results a protecting coat or covering from three-eighths to three-fourths of an inch in depth, depending on the quantity of the bituminous material used, and probably to some extent on the nature of the sand or gravel placed over it.

There seems to be ample evidence in Massachusetts that when one-half of a gallon is applied the treatment, with some patching, will last two years, and that thereafter, by applying thin coats of the bituminous material and sand every year or two, depending on the traffic, the coating may be preserved indefinitely. If this be true, the annual maintenance charges of the future, so far as the road surface is concerned, will be merely the cost of renewing the covering (probably from four cents to five cents per square yard per annum). By this method no wear whatever will take place on the broken stones, and, in a sense, that portion of the ordinary macadam road which takes the wear will hereafter be only a foundation for the bituminous wearing coat. It even seems possible that after a few years the annual cost of such renewals may be less than that of resurfacing periodically with broken stone, as has been the practice heretofore.

In new constructions, could we be sure that we will have nothing worse to contend with than the pneumatic tires of automobiles, there appears to be no reason why the old method of building macadam roads cannot be continued, provided they are given a protecting surface. And it would also seem that less care should be necessary in the selection of the stone, as concerns its quality and the sizes into which it is broken. But if the English experience is any criterion, we may look forward to a further change in the nature of the traffic. Why should not the hauling of heavy loads in the future be done by traction engines pulling long trains of heavily loaded wagons? Already it is being done in this country to a small extent, and as our systems of improved roads expand and our through roads of trunk lines become connected, why should not the traction engine trains compete successfully with the railroads? Such has been the English experience since the year 1898, when the Government, by its enactments, seemed to encourage the new method of transportation.

Should such a condition arise here, the troubles due to the motor car would be forgotten in dealing with the greater traction engine evil. The cleats or crossbars on the driving wheels of such engines, which appear to be necessary to give sufficient traction to haul the heavy loads, are the principal cause of the wear on the roads, provided, of course, the road foundations are adequate to support the extraordinary loads carried by the trailers.

The protective coat referred to would probably be inadequate for such traffic, and the introduction of bituminous binders into the voids between the broken stones would be necessary.

A good deal of work of this sort is being done now in an experimental way by mixing the bituminous material with the broken stones before they are placed on the roadway, or by grouting the bituminous material into the spaces between and around the broken stones after they have been placed and partially rolled.

Each method has its advocates, but it would seem that the first method is the surer, more exact and less wasteful of the bituminous material, and probably nearly as cheap in first cost as the grouting method, if mechanical mixers are used. Whichever method is adopted, it is usually considered that a wearing or protective covering will be required either at the time of construction or soon after.

Since both of these methods add greatly to the cost of the ordinary macadam road (probably from 20 cts. to 50 cts. per sq. yd.), and since it seems probable that in any event the roadway will require a protective covering at least as often as once in two years, it would appear to be economical to rely upon the protective covering and to omit the bituminous material from the voids between the stones, while the traffic remains as at present. And it further appears that if the macadam road is not exactly dead, it at least is now or soon will be buried under a covering of bitumen.

Steel Bands for Power Transmission.

By J. P. SCHROETER.*

Everybody who has to do with power transmission knows that our present systems, using ropes or belts, are far from being perfect. Carefully conducted experiments in the Technische Hochschule, Charlottenburg, Germany, with steel-band transmission have turned out very successfully, so that the general introduction of this kind of transmission seems to be close at hand.

It is well known that leather belts and hemp and cotton ropes are very badly affected by atmospheric conditions. They are organic materials and, in accordance with the aim of the modern designer, should be eliminated, if possible, and replaced by inorganic materials with more uniform properties. Wire ropes are only acceptable for long-distance power transmission. We know that the slip of belts and ropes is large, that the tension must be regulated very often and that the pulleys are large, taking much space and making the whole machine heavier and more expensive. The percentage of lost power is sometimes very considerable. The steel band does not show these disadvantages. It is not influenced by atmospheric conditions, an adjustment is very seldom necessary, the slip does not exceed a maximum of .15 of 1%, the efficiency is always above 99%, and the width of the pulley is considerably decreased, diminishing the space needed and saving material.

With the steel-band transmission, the distance between the pulley axles may be decreased, even until the pulleys almost touch, making it possible to use steel-bands to replace gears. The bands show no lateral vibrations and may be used at any velocities up to the highest met with in modern practice. This transmission has been used and practically tested abroad for several months.

According to the official tests made at the Technische Hochschule, Charlottenburg, with steel-bands 23 mm. wide and 0.3 mm. thick, the useful tension per centimeter of width was 15 kg. with pulleys 1,250 mm. in diameter having a peripheral velocity of 15 m. to 30 m. per second; the useful tension was 10 kg. for pulleys 600 mm. in diameter running at a peripheral velocity of 15 m. per second. The pulleys had a thin cork cover and the tension was very carefully adjusted to the most favorable conditions.

*5821 Jackson Ave., Chicago, Ill.

Expressed in English units, these results may be summarized as follows:

Belt width, ins.	Belt thickness, in.	Pulley diam., ins.	Peripheral speed, ft. per sec.	Effective pull per in. width, lbs.	Effective pull per sq. in. cross section, lbs.
.906	.0118	49.21	50 to 100	84	7,112
.906	.0118	23.62	50	56	4,742

In practice there has been transmitted with a steel-band of the above size, 145 HP and, with one 100 mm. wide, 250 HP.

There is practically no noise either at high or low velocity, and in the tests it was impossible to find any elongation of the band. Its lightness and high tensile strength permit its use at higher velocities than are permissible with belts, and its introduction for use with generators and motors has proved very successful.

An item not generally given enough consideration in calculations is the power lost in transmission. The accompanying table gives the first cost, efficiency and operating expenses with steel-bands and belt transmission.

[A brief description of the steel band transmission, which is manufactured by the Eloesser Kraftband Gesellshaft, Charlottenburg, Germany, was published in Engineering News Jan. 9, 1908, p. 32.—Ed.]

FIRST COST, FRICTION LOSSES AND OPERATING EXPENSES FOR STEEL-BAND TRANSMISSION OF 100 HP.

		Rope.	Leather.	Steel
First cost	Pulleys	$177.00	$96.00	$60.00
	Belting	148.00	310.00	180.00
	Total	$325.00	$406.00	$240.00
Losses	Loss in per cent	13	6	0.5
	Loss in HP.	13	6	0.5
	Loss per annum in HP. hours.	39,000	18,000	1,500
	Money loss	$663.00	$306.00	$25.05
Yearly expenses	5% interest on first cost	16.25	20.30	12.00
	10% depreciation on pulleys	17.70	9.60	6.00
	20% depreciation on belting	29.60	62.00	36.00
	Friction loss as above	663.00	306.00	25.50
	Total yearly	$726.55	$397.90	$79.50

Note: Diameter of pulleys, 3.28 ft.; distance between axes, 32.8 ft.; cost per HP.-hr., 1.7 cts.; 200 r. p. m.

COST OF REPAIRS TO STEAM SHOVELS.—Repairs to steam shovels at the Empire shops [on the Panama Canal] during the fiscal year 1909 cost only ⅞ ct. per cu. yd. of material excavated. The total cost of these repairs was $197,612, and the material excavated amounted to 22,583,099 cu. yds. The shop cost does not include the cost of repairs made in the field or that of repairs made to steam-shovel parts taken to the shops while the shovel is kept in service by substituting other parts. These repairs are known as field repairs and are made in the field shops and on the work, often while the shovel is waiting for cars.

A statement of the cost of steam shovel repairs in the three construction divisions from January, 1908, to June, 1909, inclusive, a period of 18 months, follows:

Item.	Divisions. Central.	Atlantic.	Pacific.	Total.
Cu. yds.	27,752,750	4,148,907	1,980,069	33,881,816
Field cost.	$596,069.02	$51,786.74	$19,917.58	$667,763.34
Shop cost.	283,746.76	51,782.61	22,246.75	357,776.12
Cost per cu. yd.	Cts.	Cts.	Cts.	Cts.
Field	2.14	1.25	1.01	1.97
Shop	1.02	1.25	1.12	1.06
Total	3.16	2.50	2.13	3.03

The shovels in the Central Division are subjected to harder and more constant usage than those of the other two divisions. Of the 101 steam shovels in the Canal and Panama railroad service 61 are in the service of the Central Division, most of them in Culebra Cut.—"Canal Record," Sept. 29.

A STEEL BRIDGE IN AFGHANISTAN.—The first iron and steel bridge in Afghanistan has just been completed by Messrs. Burn & Co. at the Howrah Ironworks, India. It crosses the Kabul River at the mouth of the Dhroontah gorge about seven miles from Jallalabad. The structure has a span of 306 ft. between centers of the towers. Blasting operations for the foundations and roadway were commenced on March 1, 1908, and continued until April 22, 1908, when the abutment on the Jallalabad side of the river was finished with the foundation bolts built in ready to receive the top foundation stones. Work was then stopped for the summer as the services of the workmen were required in Kabul. Operations were recommenced on December 1, 1908, and the bridge was finally completed and opened on February 28, 1909, but the roadway on the Lagma side of the river was not completed until a month later, as there was a great amount of rock blasting to be done. From the above it will be seen that the actual working time for erection was five months.—"Iron & Coal Trades Review," Sept. 17, 1909.

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According to recent newspaper reports from the Pacific Coast, the residents in the Imperial Valley in Southern California are in serious peril through the possible cutting off of the water-supply from the Colorado River. In the words of the despatch,

> If the Colorado River should go on one of its tangents, the entire region would starve for water within 48 hours. The channel from the Colorado River is filling with silt and becoming more clogged every hour, despite the efforts of two giant dredges working night and day. The river has changed its channel and threatens to move still farther away from the canal intake, leaving a ridge of sand perhaps a mile wide between it and the canal intake.

We have not had time, up to the hour of going to press, to verify this report, but from the accounts of the Colorado River situation published in this journal two years ago, at the time of the closure of the Colorado River overflow into the Imperial Valley, there is nothing improbable in the above story.

It will be recalled that the irrigation company which draws water from the Colorado to supply its canal leading down the Imperial Valley, had the greatest difficulties in preventing its canal from silting up, and that it was the attempt to establish an open connection without a head-gate which first started the whole flow of the Colorado down into the Salton Sea. The lesson of that unfortunate experience is, of course, well learned, and, it is safe to say, no more water will be drawn from the Colorado except through head-gates; but the liability of the river to wander over a wide stretch of territory and the difficulty in controlling it because of the shifting sand of its bed, are well understood. Thus there is nothing impossible in the report that the river might take a notion to leave the canal intake high and dry.

There are said to be some 10,000 settlers in the Imperial Valley, and they have little appreciation of the slender thread on which their property and their homes rest. Should the flow of water down the canal be cut off, the region would promptly return to the desert condition from which it was rescued a few years ago. So far as can be seen, the only hope of a permanent and reliable water-supply for the Imperial Valley would be to secure it from the dam of the Government Reclamation Service at Laguna, above Yuma. But it would take much time to establish such a connection, even if it is practicable at all, which is more or less uncertain. The difficulties of making an equitable arrangement between the present owners of the Imperial Valley canals and the Reclamation Service authorities would also be very great.

May a state control its own natural resources to the extent of preventing their sale outside the state? This question is likely to be brought before the courts with reference to the supply of water from New Jersey to Staten Island, a part of New York City. Geographically, Staten Island really belongs to New Jersey. It is separated from it only by a narrow tidal channel, the Kill von Kull. It is separated from New York, however, by the whole breadth of New York harbor and from the Long Island shore by the half mile distance across the Narrows.

Staten Island, therefore, is dependent upon New Jersey for the water supply which is becoming urgently necessary to supplement the inadequate supply obtained on the island itself. The State authorities of New Jersey, however, have endeavored to prevent the delivery of water to Staten Island, claiming that the available supply should be reserved for the State's own people. The State courts have been inclined to look favorably upon this claim. It seems extremely improbable, however, that the same view would be taken by the Federal Courts. If a State may legally place a bar on the export of any of its products across the state boundary, then free trade between the several states, and with it real national unity is in serious danger. If New Jersey may prevent or even place an export tax upon the delivery of water from the state to New York, then Pennsylvania might raise revenue for the political oligarchy which rules it by taxing the anthracite sent across its borders and Montana could tax the shipments of copper from its mines and smelters.

A contributor in another column describes some German experiments with flat steel bands for power transmission in place of ordinary leather belts. The experiments showed very favorable results and the matter seems to be worth the attention of American engineers. Good precedent exists for the use of such transmissions in the modern band saw. The power transmitting belt is merely a band saw without teeth. An efficiency of 99½% is claimed for the transmission; but it is manifest that this must be for the belt alone, and no account can be taken of the friction in the shaft bearings caused by the pull of the band. To get the true efficiency of a power transmission this should be included.

In most cases where belt transmission is used it is desired to use tight and loose pulleys for starting and stopping. The steel band would hardly be adapted to such situations and its use would have to be confined to the places where positive connection between two parallel shafts is desired. Where these conditions exist the steel band transmission may be very useful to the mechanical designer.

A few weeks ago the New England newspapers were filled with long accounts of a new process for the utilization of Rhode Island coal. As some of our readers may be aware, there are great deposits of anthracite underlying the State of Rhode Island, but it is an anthracite which has been so far changed to the graphitic form that it is practically incombustible. Many attempts have been made to burn it, but they have met with uniform ill-success. We recollect, indeed, to have heard a saying, said to be current in Rhode Island, that when the world is destroyed by fire the Rhode Island anthracite will be the last thing to burn.

Now, however, a concern known as the Rhode Island Coal Co. claims that it has obtained control of a process by which the coal can be made readily combustible. It was stated that preparations were under way to work the mines upon a large scale, and a large stock issue was offered for subscription to investors.

Our contemporary, "Power and the Engineer," in its issue of Oct. 5, reports the results of an investigation of this new process for burning coal—and possibly also burning innocent investors. The result of our contemporary's investigation was to show in general that, while extensive plans had been made for the development of the plant, located near Portsmouth, R. I., not very much had actually been done as yet.

Regarding the alleged combustibility of the Rhode Island coal after treatment, the claim was that the coal became combustible when given a bath in a 5% solution of sodium nitrate and calcium chloride. While the sodium nitrate contains some oxygen, it seems doubtful whether the trifling amount obtained from the weak solution proposed could be of any material value in assisting the coal to burn. Briquetting the coal with a binder might possibly make it combustible, but this remains to be proven, and our contemporary's warning, that investors contemplating purchase of the company's shares would do well to investigate for themselves, seems well advised.

The relations between railways and waterways is one of the subjects to be discussed at the meeting of the International Railway Congress in Switzerland next year. We give in another column an abstract of a paper on this subject which is to be presented dealing with conditions in Great Britain and in India. It appears that in England the traffic of inland waterways is small and is diminishing. It might be increased by improving the waterways, but such improvement does not appear to be warranted in view of the great cost which would be involved. This opinion is confirmed very strongly by evidence which has been given during the past two or three years before a Royal Commission on inland navigation. Experience in England ought to be studied in this country before we accept the ideas regarding waterways which are being disseminated all over the country by the waterway boomers.

The Growth of Exports from Gulf Ports.

Statistics of the export trade of the United States, issued by the Department of Commerce and Labor on Oct. 11, show that the exports from the Gulf ports increased 112% in the ten years from 1899 to 1909. During this same ten years, the Atlantic ports increased their exports only 12%.

Without doubt these figures will be made use of by the commercial organizations of New York, Philadelphia, Boston and Baltimore, as an argument to prove that these cities are falling behind in the race for commercial supremacy. Upon these figures will be based appeals for government appropriations for harbor improvement and municipal appropriations for docks and wharves. There will also be appeals to the railways for more favorable rates in order that the Atlantic ports may regain some of the traffic which is now going southward.

It seems worth while, however, to take a broader view of this change in the currents of commerce. It should be clearly understood, in the first place, that the Atlantic ports have shown an actual gain in the ten years. They cannot claim that trade has been diverted from them which they formerly possessed. Further, if they are wise enough to look at the matter in a broad way, they must recognize that the growth of trade through the southern outlets to tide-water is a natural and healthful development. No other result could be expected, when one considers the enormous growth that has taken place during the past quarter-century in the production of that great fertile area west of the Mississippi. This vast district, teeming with agricultural wealth, including Texas, Oklahoma, Arkansas, Missouri and Kansas, is located many hundred miles nearer to the Gulf of Mexico than it is to any Atlantic seaport. Further than this, the haul to the south is over lines of easy grade, whereas goods carried to the Atlantic must either cross the Alleghany Mountains, or else make a long detour to the north to reach the route through the Great Lakes. There are other handicaps to shipment through the densely crowded ports of New York and Boston. The expense of

handling shipments of bulk freight is and must inevitably be much higher in such harbors than in the roomy waters of the new ports on the Gulf. At the Northern ports, too, there are difficulties in the winter months with ice in the harbors and with snow on the railway lines reaching them. The large range of tides is also a factor of some importance in handling vessels in a North Atlantic port, compared with the almost tideless waters of the Gulf.

To offset all these advantages, there is, of course, several hundred miles' longer sea voyage from the Gulf ports to Europe. But these added miles in the sea voyage mean a mere trifle in the total cost of carrying a bushel of grain or a bale of cotton from a Texas farm to a European wharf.

It is surely not strange, when all these things are considered, to learn that Galveston, which sent abroad 78½ million dollars' worth of exports in 1899, sent abroad 189½ million dollars' worth in 1909. New Orleans, which sent 86¾ million dollars' worth abroad in 1899, sent 145 millions in 1909. Mobile shows an astonishing growth in her trade. Her exports, which were a little short of 9 million dollars in 1899, rose to over 27 millions in 1909. There are new Gulf ports, also—so new that few outside of commercial circles have ever heard of them. Pearl River, Miss., for example, exported 7½ million dollars' worth of goods in 1909. St. Marks, Fla., which shipped abroad four thousand dollars' worth in 1899, sent 1⅛ million dollars' worth in 1909, the increase being due entirely to the development of the Florida phosphate industry. It is fair to point out that a part of this growth in the decade is due to a considerable increase in the average values of the goods exported, as well as to the increase in their volume.

This vast growth in the trade of the Gulf ports is full justification of the expenditures made by the Government upon their improvement during the past quarter-century. It ought to be fully understood, however, that it is because natural conditions favored the growth of trade in this direction that the growth has occurred, and it is absurd to argue that similar expenditures made on the Atlantic ports would have brought the trade to them instead.

The commercial organizations of New York and other ports on the Atlantic will do well to take a broad view of this matter and treat it without sectional jealousy. If they wish to retain trade, they should keep down, so far as possible, the expense of handling traffic in their cities; but they should not expect by any possible facilities or economies to attract trade which naturally seeks other channels.

New Encouragement for Apprentice Training.

It has been generally believed, until recently, that labor organizations in this country have favored neither the training of ample numbers of apprentices in the vocations commonly known as "the engineering trades," nor adequate instruction of the small number of apprentices they approved of. It has been generally conceded that the rules of labor unions, limiting the number of apprentices in these trades, have been made to prevent any chance of a surplus of skilled workmen, and so that the aging workmen should not face the possibility of unemployment or diminished pay before the marked appearance of senile debility. It is evident that such movements have been useless and futile. The growth of manufacturing in this country has been so great that thousands of ready-trained foreign-born mechanics have been attracted here, and it has not been necessary to retain unfitted native-born artisans. All this time, on account of the short-sighted policies of both labor leaders and manufacturers, many of the boys who might have received a broad training as mechanics have been made single-tool operators—factory cogs. Others have been made to adorn various mercantile niches, while the less alert and those unable long to follow the public schools have been forced into the ranks of unskilled labor.

Until recently there have been few manufacturers who have been anxious to give their future workmen a general training in their trade. Some were willing to give a very special, narrow sort of instruction, long enough to get single-tool hands. More preferred to receive their help ready trained, believing this the cheapest and least bothersome plan.

Now it is seen that shop apprentices pay well during the period of training. It is recorded that under proper supervision they can do the work of single-tool men who are earning fair wages. To secure this condition, the shop manager must have confidence in his apprentice system, must furnish the apprentices with the best of instruction, and must entrust actual production to them. It has been found that under these conditions the boys meet the responsibility imposed and do not merely waste good material in the days before they become journeymen mechanics. When the boys "graduate," too, they are found to have a feeling of loyalty for "the old shop" akin to that with which a collegian regards his alma mater.

There are now indications all along the line that the old distrust of broad, but specific, apprentice courses is disappearing. If these evidences have been rightly judged, then those pessimists may rest who have seen only doom for the American manufacturer when the superabundant resources of this, a fresh land, are brought down nearer to those of older lands across the seas.

Recent discussions in the several engineering associations disclose the opinions of several large manufacturers that it is better for them, and for their workmen, to have a broad grasp of their trade than merely an intimate working knowledge in a very limited field. A feeling is disclosed that it has been an unfortunate tendency all around that has produced single-tool operators only. These workmen have not been found resourceful in emergencies, and a shop force of such men cannot be readily adapted to changes in demand and consequent changes in the character of work done.

An official report of a Committee on Industrial Education of the American Federation of Labor has reported strongly, although in general terms, in favor of industrial training in the public schools and for teaching the principles of mechanics to those who intend to enter the so-called "engineering trades." It is notable that this committee of the American Federation wants "industrial education," but it is silent as to "shop training." Do the labor unions want general education without apprenticeship—theory without practice? Do they realize that any industrial education without well-directed or good, practical experience in the shop will make the boys superficial in their mechanical ability. Or are the labor leaders now at last taking a more liberal view of all industrial training, and is this committee report but preliminary to others which will formally disclose a more broad-minded view of industrial needs?

The recommendation that the "elements of mechanics" be taught in the public schools has a curious sound. The subjects conceded to be of most immediate and primary utility to a good, all-around mechanic—an educated mechanic, if you please—beside the actual training of the hand to the work, are the elements of mathematics, drawing and language. After these in usefulness are believed to come simple physics, chemistry and civics, and, lastly, the other natural sciences, literature, art. Now, mechanics is but a part of physics, dealing with mechanical forces and motions. Understanding of mechanics is called for less often than knowledge of language, of mathematics or of drawing. Indeed, some knowledge of these three is essential for an approach to mechanics. It is desirable in training an apprentice that instruction in the first group should first be given, followed by the second group, and, finally, by the third as opportunity offers.

Some educators contend that a man is "educated" when he can do some one thing well. Using this proposition as a basis, it has been claimed that industrial education should be directed toward some definite trade, and that attempts to impart a smattering of many things should be eliminated. This statement is often perverted to mean that the training must be narrowing to an extreme, but such perversion is unnecessary.

Granted that it is well for youths to be trained for a specific trade, it is also well that the training shall be broad enough for the man to understand the principles which are to govern his more or less mechanical actions, and that tastes for aesthetic pleasures and desires for civic service should be implanted and encouraged. Such things have been too often regarded as exclusively coincident with "higher education."

A trade school, according to present accepted definitions, must confine itself to those things which relate closely to the occupation which a pupil elects. But even the trade school, in teaching the principles on which a trade depends, can implant the beginnings of science and language at least. An industrial school, so-called, is perhaps a less restricted institution, and here it may be reasonably held legitimate to implant more specifically the seeds of civic usefulness and of aesthetic pleasure. Whether a city shall establish a "trade" or an "industrial" school, is to many a vexing question. Local conditions may determine the fairness of the distinction. In some cases it may be just that the public shall train up machinists and foundrymen and carpenters and not masons or printers or bakers. That would be perhaps where the welfare of the city depended most on the number of machinists and foundrymen and carpenters in its industries. Then such a proportion of taxes could justly be diverted as would represent the contributions of this element of the population.

LETTERS TO THE EDITOR.

More Experience with Petrolithic Pavements.

Sir: I have noted with interest the letters published in your issue of Sept. 23, relating to petrolithic pavements at El Paso and Los Angeles.

Having myself not only made a careful investigation and study of this type of pavement, but actually been engaged in its construction, I was not surprised at some of the "revelations" made by Mr. Campbell. My knowledge of petrolithic construction, in common with that of Mr. Campbell, has included examples of poor results and even failures; but I have also seen many instances where poor selection of material or poor workmanship has resulted in the failure of macadam and asphalt roads.

Good materials and good workmanship are a *sine qua non* for good results, and the fact that one or a dozen petrolithic roads give unsatisfactory results is not in itself a sufficient reason for condemning that type of construction.

It is evident from the recommendations both of the City Engineer and the Inspector of Public Works of Los Angeles that a petrolithic pavement containing a certain amount of gravel (be it "natural" or supplied) when properly built is one which can be investigated with advantage to the road-using public.

My own experience in this line has shown that when proper care is taken in the proportioning of the materials and in the construction, most satisfactory results can be obtained.

I heartily agree, however, with Mr. Campbell, Mr. Hamlin, and Mr. Humphreys, as well as the Petrolithic Pavement Co. themselves (who are evidently learning by experience), that it is not possible to make a serviceable road out of any strip of dirt taken at random unless the proper materials are added.

In closing I might say that the company with which I am connected merely leases equipment from the Petrolithic Pavement Co. of Los Angeles, and is in no sense a branch or off-shoot from them, and inasmuch as we are not, and do not expect to be on the downy side of any political "ring" we shall be the first to abandon petrolithic construction if we find that satisfactory results cannot be obtained.

Yours very truly,

A. S. Malcomson.

37 Railroad Ave., Freeport, N. Y., Sept. 28, 1909.

Sir: Judging from Mr. J. L. Campbell's letter of Aug. 5, 1909, published in your issue of Sept. 23, last, it appears that he does not believe that I told the truth concerning petrolithic pavements in my letter to you, published July 29; presumably because I am interested in their adoption and construction. I beg to ask Mr. Campbell, if it is not possible, in these latter days, for one to speak truth even though one may be interested, financially, in that of which he is speaking?

In my letter to you, some points of which Mr. Campbell criticises, I was extremely careful to make no statements the truth of which I could not substantiate. I am not "exploiting" this pavement in Georgia, nor elsewhere, to draw an illegitimate profit therefrom; but I am seeking to introduce it here in order to cheapen and to better the roads of this state, and to make a living by constructing it. Is that wrong?

Byrne, in his "Highway Construction" says that, "The object of a pavement is (1) to secure a water-tight covering that will preserve the natural soil from the effects of moisture, * * *; and (2) to furnish a smooth surface on which the force of traction will be reduced to a minimum"; and he further says that, "The qualities essential to a good pavement may be stated as follows:

1. It should be impervious.
2. It should afford a good foothold for horses.
3. It should be hard and durable, so as to resist wear and disintegration.
4. It should be adapted to every grade.
5. It should suit every class of traffic.
6. It should offer the minimum resistance to traffic.
7. It should be noiseless.
8. It should yield neither dust nor mud.
9. It should be easily cleaned.
10. It should be cheap."

Notwithstanding what Mr. Campbell says adversely concerning the petrolithic pavements these pavements fulfill the objects and embody the essential qualities of pavements, as expressed by Byrne, to a very high degree, as is proved and absolutely demonstrated by these pavements in the cities of Monrovia and Ventura, Calif., where they may be seen by whomsoever so desires.

In my previous letter to you, I said,

"whether the material is soil, sand, gravel, worn-out macadam or other granular and stable material, makes little difference as to the final good character of the completed pavement."

This statement, although it does not meet the approbation of either Mr. Campbell or Mr. Homer Hamlin, City Engineer of Los Angeles, Calif., nevertheless is still true, and is fully substantiated by the pavements on the streets of Monrovia and Ventura, above cited, for the reason that they are well constructed with an oil of good quality and because broken stone is properly incorporated therein.

If these gentlemen had carefully read my previous letter, they must have noticed that I did not fail to mention the reason and the necessity for the use of the broken stone in, and the non-absorbent wearing surface on, the pavement.

Mr. Campbell has laid claim to considerable knowledge concerning petrolithic pavements and has quoted Mr. Hamlin as well versed also in this matter, but neither of them has cited specific and authentic instances of failure; therefore, I demand of them to support and corroborate their claims and opinions by duly accredited citations of the failure of these pavements, where the latter have been properly constructed with an oil of approved quality ("Adaline" or "Sunset") and a wearing surface of stone screenings.

Mr. Campbell quotes Mr. Hamlin as follows, as regards the petrolithic process: "There is a great difference in the character of results accomplished with this process even on the same street." With just as much truth could he have said the same of asphalt or bitulithic pavements, as every one who has observed the behavior of pavements will testify.

I do not wish to be understood as defending the surface-oiled earth road, which neither of these gentlemen seem able to differentiate from the petrolithic pavement as constructed in accordance with up-to-date practice and the best experience, to which I had sole reference in my letter to you.

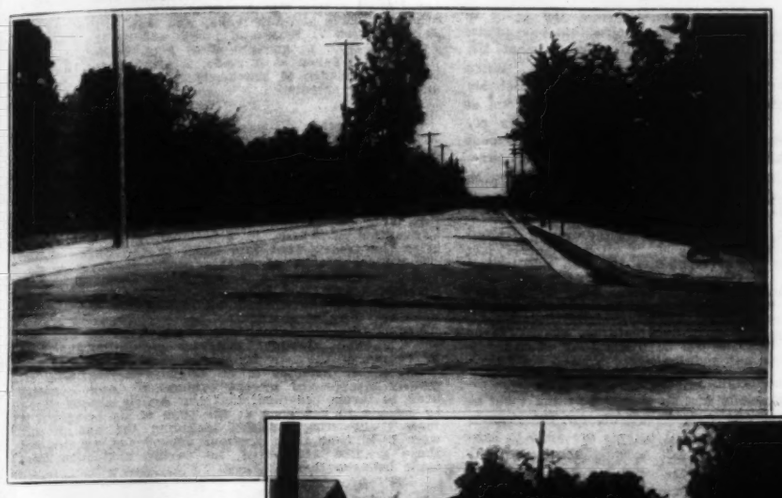
When these pavements are so constructed, their results are uniform and satisfactory, when an oil of a proper quality is used therein, which is amply and irrefutably proved by the pavements cited above. Had Mr. Hamlin ascribed the different results, obtained by this process, to the character of the oil rather than to that of the soil, to my mind he would have been much nearer to the truth, provided, of course, he referred to those pavements wherein broken stone or gravel had been incorporated near, or on, the surface of the pavement.

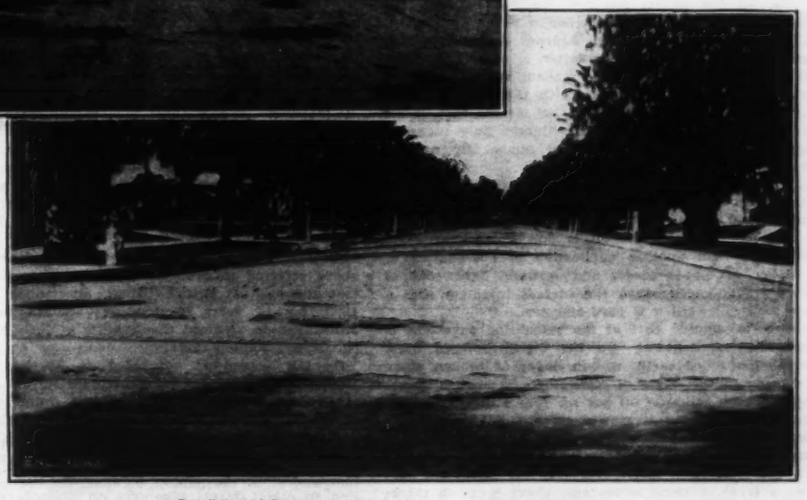
As to Mr. Campbell's photographs: If Fig. 1 is really a petrolithic pavement, then entirely too much oil was used therein, which could and should have been detected and rectified by the builders before it was left as completed. I have examined from 30 to 40 miles of these pavements, but never did I see one so rutted and buckled as the pavement which is shows in the picture, which, it appears to me, shows rather a surface-oiled road with entirely too much oil. Would you condemn all structures of a certain class from one picture of, or from what one or two men had to say adversely to, one certain structure of that class? Figs. 2 and 3 show nothing new concerning pavements. Neither asphalt nor bitulithic can withstand, for very long periods the continued stamping of horses while standing at hitching posts, without showing injury to their surfaces; neither can a petrolithic pavement be exempt from such an injury under such usage. Will the gentleman condemn a class of pavements simply because he can find a puddle of water on the surface of one of that class? If so, then he must do away with practically all pavements except granite, for I can show him such holes in nearly all pavements.

Again, Mr. Campbell questions my statement, that petrolithic pavements resemble asphalt and bitulithic pavements in their grayish black color, smoothness and evenness, when the latter are in good condition. What he says, concerning these features, proves absolutely that he has never seen a petrolithic pavement that has been opened to traffic for more than six to eight months. Had he ever seen these pavements on Slauson Ave., Los Angeles, or Thompson Ave., Ventura, or those on the streets of Monrovia, Cal., he could not have written what he did concerning this point, for it is evident to any one, who may see them, that my statement is absolutely true, regardless of what he may imagine from the present condition of Wyoming Ave., El Paso.

Mr. Campbell has much to say about the present surface conditions of the petrolithic pavement on Wyoming Ave. Every one acquainted with the construction of these pavements knows that much of the loose finishing course of screenings is ground up and washed away before the surface attains that true, hard and asphalt-like surface to which I referred. The same thing is true, identically, concerning the surface of new bitulithic pavements, as I have seen them constructed here in Atlanta. If Mr. Campbell will wait for a few months, he will see this result on Wyoming Ave., unless a poor and worthless oil has been used thereon.

The gentleman has not grasped the true idea of the construction of these pavements. If he had considered all the points that I brought out in my previous letter, he would have seen that I demanded an impervious and non-absorbent wearing surface consisting of the hardest and toughest stone available. Next, I demanded a layer, at least 2 ins. thick, of broken stone, beneath the wearing surface, to give rigidity to the pavement in the same manner as well-bonded broken stone gives rigidity to a properly constructed macadam pavement; which layer of stone, from the fact that it is most perfectly consolidated by the roller tamper and has its interstices filled with oiled earth, thus becomes absolutely impervious. Lastly I demanded that the remaining 3½ ins. of the 6-in. pavement be oiled and tamped solid so as to further give a rigid and impervious base to the pavement. This is not mere theory, but is actual practice as shown by the pavements on the streets above cited, which have stood the test of time and usage. In my statement that, "Whether the material is soil, sand,





OILED MACADAM STREETS IN RIVERSIDE, CAL.

gravel, wornout macadam or other granular and stable material, makes little difference as to the final good character of the completed pavement," it was understood, of course, that the pavement is to be constructed according to my description and with an oil of good quality, and this, of course, was implied and understood when I wrote my previous letter.

I do not claim, by any means, that all of the petrolithic pavements that have been heretofore constructed are a success; but I do aver, that those to which I have referred and those that have been properly constructed, give conclusive evidence that these pavements are cheap, durable, efficient and capable, to a very high degree, of resisting the destructive effects of traffic and weather.

Of all the petrolithic pavements that I examined while in California, for the especial purpose of studying them, those that I saw in Los Angeles were among the very poorest. Probably the most important street paved in that city with this pavement is West Adams St. The pavement thereon, although it had broken stone incorporated, is a partial failure. One reason therefor is apparent, because it is not provided with a wearing surface of stone screenings cemented with a good oil. While this pavement was under construction, Mr. W. A. Gillette, of the Petrolithic Pavement Co., of Los Angeles, notified the then city engineer of that city, that this pavement was not being properly constructed. This pavement could be put in excellent condition for about 20 cts. per sq. yd., and would then last for years. By the citation of this one instance in Los Angeles, I desire to show that the construction of these pavements in that city may not have been as carefully done as it should have been, which may account for Mr. Hamlin's poor opinion of this kind of pavement.

Mr. Hamlin condemns the petrolithic pavement (in his letter to Mr. Campbell, quoted above), yet in his report to the Board of Public Works of Los Angeles he approves it as secondary to oiled macadam; but he says in that report that oiled macadam "must not be considered as a pavement in the strict sense of the term." If oiled macadam is not a pavement, What is it? Concerning oiled macadam, Mr. Hamlin shows that:

1. It is impervious;
2. Implies that it gives a good foothold for horses;
3. Shows that it is hard and durable, because he says it will resist the destructive effects of automobiles;
4. It is the most noiseless of street pavements;
5. Implies that it is a dustless pavement.

Therefore, according to his own description of oiled macadam, it possesses five of the ten essential qualities of a pavement, as laid down by Byrne, and yet Mr. Hamlin says that it is not a pavement in the strict sense of the term. Evidently the gentleman should coin a word or two if he cannot reconcile Webster's definition of the word "pavement" with the character of oiled macadam.

Let us briefly compare oiled macadam, as recommended by Mr. Hamlin in his specifications No. 79, with the petrolithic pavement as constructed in Ventura, Cal.

(1) According to his own figures, the former will cost 1⅝ times as much as the latter.

(2) The base of the oiled macadam consists of oiled earth, which is to be tamped with the roller tamper; precisely the same method is adopted for the base of the petrolithic pavement. Herein Mr. Hamlin duly acknowledges the advantages of the roller tamper for making the base of the pavement.

(3) On this base (for the oiled macadam) a 3-in. layer of broken stone is spread, and is then rolled with a plain road roller, is then oiled with ¾ of a gallon of oil per sq. yd.; over the oil is laid a layer of stone screenings, then another application of one-quarter of a gallon of oil is made, and another light coat of screenings is added; then the surface is rolled with a plain road roller till it is hard and firm.

The corresponding part of the petrolithic pavement is constructed as follows: On the 4½-in. tamped base, composed of oiled earth, a 2-in. layer of broken stone is spread; to this layer of stone there is applied three-quarters of a gallon of oil per sq. yd.; 1 in. of the previously tamped base is plowed up and mixed with the stone; the stone and loose oiled earth are then thoroughly compacted with the roller tamper; after which one-half of a gallon of oil is distributed over the compacted surface; a layer of stone screenings, about ¾-in. in thickness, is spread over the oiled surface, which is then rolled until the surface is hard and compact; or else, the street is opened to traffic and the compacting of the screenings is left to be done by the said traffic. Thus it is seen, that the surfaces of the two pavements are identical in methods of construction and in the materials used; and that the top 3 ins. of the oiled macadam will be left with from 15% to 20% of voids therein, which no amount of, nor long continued, rolling with the plain road roller will lessen to any appreciable extent; and that, when the surface is opened to traffic and has to sustain loads on narrow tires, it will be found that unequal and irregular depressions will occur in the surface of the pavement, and that these depressions are due to the fact that it is impossible for the plain road roller to thoroughly and uniformly compact the broken stone layer. This is shown to be true by the condition of some of the oiled macadam streets in Riverside, Cal.; in evidence of which I enclose some photographs, which I snapped in that city on June 18 last. This same result I noticed on an oiled macadam street in Pasadena, Cal.

In the petrolithic pavement, the lower 2 ins. of the upper 2½ ins. having been tamped by means of the innumerable applications of iron feet or shoes, each of about 4 sq. ins. area and bearing a weight of about 450 lbs., and having all of its interstices filled with oiled earth, is hard, firm and impervious and is practically free of voids; consequently this layer of stone possesses a rigidity and density surpassed by neither oiled macadam nor by bitulithic pavements.

The wearing surface being identically the same in both the oiled macadam and the petrolithic pavements, I desire to call Mr. Campbell's attention to what Mr. Hamlin says of the surface of the former, viz.: "When properly constructed, the casual observer will probably not note any difference between this surface and one of asphalt." This fully corroborates what I said in my original statement, viz.: "The petrolithic pavement strongly resembles sheet asphalt and bitulithic pavements in their grayish black color . . . . when the latter are in good condition."

Concerning oiled macadam, Mr. Hamlin further says, "The surface is, however, more elastic" (than asphalt by the text above) "and the sharp click of horses' feet is deadened far more completely than on an asphalt surface. It is, in fact, one of the most noiseless of street pavements. The oiled surface prevents washing or gullying by running water, sheds the water off the street like the roof, and thoroughly binds the material in place. These are important features, especially the last, as it will prevent the destruction of the surface by rapidly moving automobiles."

All of which quotation is just as applicable to petrolithic pavements and is just as true concerning them as it is of the oiled macadam pavement, for the reasons that the surfaces of the two pavements are alike in construction and materials; and because the petrolithic pavement is of a more homogeneous and firm character, it is, therefore, decidedly more impervious and rigid than oiled macadam. Consequently, it follows that Mr. Hamlin has no foundation whatever for his opposition to, and his criticism of, the petrolithic pavement.

I claim, Sir, that the letter of Mr. Campbell and the report of Mr. Hamlin, which you strongly endorse editorially, do not present to your readers the petrolithic pavement in a fair and impartial manner, as an examination of the many miles of these pavements in California will prove to the unbiased mind.

I do not criticize nor do I condemn the oiled macadam pavement, but I found it to cost more than, and that it would not hold its surface as well, nor as long, as the petrolithic pavement—hence my approval of the latter.

Yours truly,

D. Lee Wardroper.
Civil Engineer.

326 Candler Bldg., Atlanta, Ga., Sept. 29, 1909.

Life of the Cameron Septic Tank Patent. A United States Patent Does Not Expire at the End of the Shortest Foreign Patent.

Sir: The statement has been frequently made that United States patent No. 634,423, covering the Septic Process, granted to Messrs. Cameron, Gommin and Martin, and now owned by the Cameron Septic Tank Co., of Chicago, Ill., expires in November, 1909. The patent in question was issued Oct. 3, 1899, for 17 years, and has, therefore, now seven years to run. The statement above referred to probably had for its origin the fact that the original British patent, granted in November, 1905, for 14 years, expires next month, and it has probably been assumed that the life of the United States patent was limited thereby.

By the convention concluded at Brussels, Dec. 15, 1900, by the International Conference for the Protection of Industrial Property, at which the United States was represented, it was among other things ordained:

Art. 4 bis. Patents applied for in the different contracting states by persons admitted to the benefit of the convention under the terms of Article 2 and 3 shall be independent of the patents obtained for the same invention in other states, adherents or non-adherents to the Union.

This provision shall apply to patents existing at the time of its going into effect.

The same rule applies in the case of adhesion of new states to patents already existing on both sides at the time of the adhesion.

The provisions of this treaty were duly ratified by the Senate, proclaimed by the President of the United States, and thereby became the law of this country.

In United Shoe Co. vs. Duplessis Shoe Co., 155 Fed. 842, however, it was held by the Court of Appeals of the first circuit, that although Art. 4 bis on its face was self-executing, it was controlled by implication by the Act of March 3, 1903, in which the clause making this provision of the treaty retroactive was omitted.

This construction of the treaty is probably responsible for the statements that have been made regarding the premature expiration of the Cameron patent. A decision of the U. S. Circuit Court of Appeals in Philadelphia, however, recently handed down in Hennebique Construction Co. vs. Myers, by Judge Archbald, holds that the treaty of Brussels was self-executing and freed all United States patents existing at the time it went into effect from the limitation of their terms by reason of prior foreign patents. Under this decision the Cameron patent in the United States is independent of the earlier British patent, and will not expire until Oct. 3, 1916.

The following excerpts from Judge Archbald's opinion are of special interest:

This convention (at Brussels) was additional to that similarly concluded at Paris March 30, 1883, to which the United States was not originally a party, but subsequently gave its adherence; and was ratified by the Senate March 7, 1901, and proclaimed by the President Aug. 25, 1902, to go into effect Sept. 14 following. 32 Stat. 1936. Taken as it reads, it provides for the absolute independence of previously interdependent domestic and foreign patents. . . .

. . . . . .

Without further discussion, therefore, it is clear, that Article 4 bis, having been duly ratified by the different states, represented in the Conference, in the form in which it now appears, must be taken as it reads, according to which the dependence of domestic on foreign patents for the same invention, previously granted abroad, is entirely removed and done away with. And this is to be interpreted liberally. As resolved by the Convention of Turin, in September, 1902, a few days after the treaty went into effect in the United States: "The independence of patents proclaimed by the additional Act of Brussels ought to be construed in the broadest terms, and particularly in such manner that the term of a patent shall not in any case be dependent upon the term of another patent."

Nor is this to be confined, as conceived by our delegates, to such subsequent incidents as nullities and lapses by reason of the non-payment of renewal fees or non-working, an attempt to so limit it having been expressly disapproved by the conference. And it having been in terms provided, that the Article should "apply to patents in existence at the time of its being put in force," subsisting patents, including the one in suit, were freed from their previous dependency, equally with those granted afterwards, no saving distinction being made between them.

. . . . . .

In the United Shoe Co. vs. Duplessis Shoe Co., 155 Fed. 542, it was held by the Court of Appeals of the First Circuit, that, although Art. 4 bis on its face was self-executing, it was controlled by implication by the passage by Congress of the Act of March 3, 1903, to give effect to it. But neither of these views in my judgment can be sustained. Having respect to their terms, it cannot be said, that either the Treaty of 1883, or the additional Act of 1900, required legislation here to make it effective. They both undertake in the most direct and positive way what shall and what shall not be as to the matters with which they deal, and being ratified in that form, nothing further, by our laws, was necessary to put them into operation. They cannot be treated as mere agreements by the high contracting parties to bring the domestic laws of each into conformity with them by subsequent action. That resulted by virtue of their own force and vigor. A treaty is a law of the land as an Act of Congress is, whenever its provisions prescribe a rule by which the rights of the private citizen or subject may be determined. Head Money cases, 112 U. S. 580, 598. . . .

. . . . . .

Taking Treaty and Acts of Congress together, therefore, the case stands this way: "By Sec. 4887 Revised Statutes, a domestic patent for the same invention previously patented abroad, was made dependent on the term of such foreign patent, by which it was limited. The Act of March 3, 1897, removed this restriction, but provided (sec. 8), that it should not apply to patents granted prior to Jan. 1, 1898, nor to applications filed before that on which patents were subsequently granted. . . ." Then the additional Act of Brussels of 1900 was ratified, by which, according to Art. 4 bis, there was a complete unfettering of foreign and domestic patents for the same invention; and this by express terms was made to apply to existing patents. Such was the state of the law, and such the position of the patent in suit, when the Act of March 3, 1903, came into existence. As just stated, this could not undo what had already been done, nor put back the patent into its former dependent condition. Having become entitled to the full term of 17 years accorded to patents generally, it could not thereafter be again restricted. Nor did the Act of 1903, indeed, undertake to do so. It simply re-enacted Sec. 4887, as amended by the Act of 1897, leaving out the limitation which time and treaty had doubly disposed of, and introducing certain provisions in conformity with the treaty. . . .

H. D. Wyllie.

Monadnock Block, Chicago, Oct. 9, 1909.

Notes and Queries.

In Mr. C. B. Buerger's letter entitled "Formula for the Volume of Material in Groined Arches," p. 387 of our last issue, a typographical error occurred in the ninth line of text. The first coefficient, printed as 0.942, should be 0.9042. It appears correctly in the numerical example given.

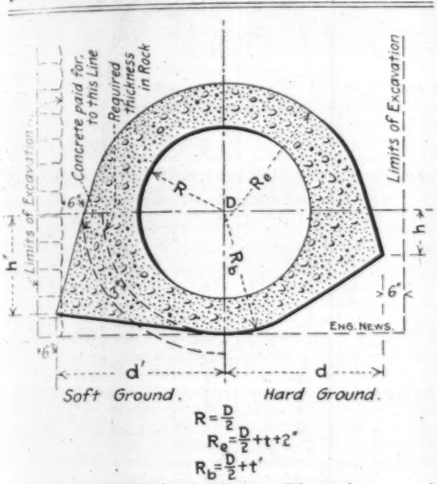
FREIGHT-CAR STATISTICS.—The decrease in number of idle freight-cars continues. On Sept. 29, as reported to the American Railway Association, the surplus of cars was 53,388, a decrease of 25,000 in two weeks. The present figure is the lowest since the end of 1907, when business depression began. Countervailing shortages totaling 14,600 cars are reported by various lines. In 1908 the decrease of the car surplus under the influence of the fall freight movement progressed until Oct. 23, reaching a low point of 110,900 idle cars.

Some Notes on the Louisville Sewerage Improvements.

By ROGER DeL. FRENCH.*

The City of Louisville, Ky., is at present engaged in extending its sewerage system, under the general direction of a Board of Commissioners of Sewerage, which is provided with funds by a $4,000,000 bond issue. Mr. J. B. F. Breed is Chief Engineer, Mr. Harrison P. Eddy, Mem. Am. Soc. C. E., Consulting Engineer, and Mr. J. H. Kimball, Designing Engineer.

The construction will eventually include about 125 separate contracts, of which fifty are completed or under construction. The greater part of the $4,000,000 is being expended in the construction of trunk sewers, such as the Southern Outfall (length 5.6 miles, 7 to 15½-ft. diameter); the Northwestern (length 3 miles, 6 to 11¼-ft. diameter); the South Louisville Branch (length 1.7 miles, 5½ to 10 ft. diameter), and the Beargrass Intercepter (Sanitary) (length 3 miles, 1½ to 6½-ft. diameter). There are, however, a large number of laterals from these trunk sewers, and many relief sewers included in the scheme.



$R = \frac{D}{2}$

$R_e = \frac{D}{2} + t + 2''$

$R_b = \frac{D}{2} + t'$

Fig. 1. Standard Sections, Dimensions and Quantities, Circular Concrete Sewers, Lexington, Ky.

D	t	t'	d	h	d'	h	Cu. yds. per ft. Hard ground.	Cu. yds. per ft. Soft ground.
24"	5"	5"	1-9"	6"	1-11½"	14"	0.15	0.19
27	5	5	1-10	7	2-0	15	0.16	0.19
30	5	5	2-0	7½	2-2	15	0.18	0.21
33	5	5	2-1	8	2-3½	16	0.19	0.23
36	5	5	2-4	9	2-6¼	17	0.22	0.26
39	5	5	2-6	10	2-8½	20	0.24	0.30
42	..	6	2-8	10½	2-11½	21	0.27	0.34
45	6	6	2-11	11	3-3	22	0.33	0.39
48	6	6	3-0	11	3-3	22	0.33	0.42
51	6	6	3-3	12	3-7	24	0.36	0.44
54	6	6	3-6	13	3-10	26	0.42	0.54
57	6	6	3-9	14	4-2	28	0.48	0.61
60	7½	6	4-0	15	4-5	30	0.56	0.72
63	7½	6	4-3	16	4-8	32	0.60	0.79
66	7½	6	4-6	17	4-11	34	0.65	0.86
69	8	6	4-9	18	5-2	36	0.70	0.93
72	8	6	5-0	19	5-5	38	0.77	0.99

BORINGS.—Earth borings are taken about every block (480 ft.) on the line of each proposed sewer. They extend at least 1 ft. below the bottom of the invert, or to rock, if rock is above this elevation. These borings are put down by a superintendent and four men, using the regular shallow-well driller's outfit, including auger, sand-pump, casing, pod drill, drill rod, derrick, etc. In many cases it is possible to get a boring down to the required depth with an earth auger alone; 28-ft. holes have been put down thus. Reports of material encountered are made on a special blank for the purpose, and samples are taken in pint Mason jars, sent to headquarters, and kept at hand for the convenience of bidders.

SECTIONS FOR SEWERS.—The standard sections for circular sewers are shown by Fig. 1, which is supplemented by a table giving dimensions and quantities for various sizes. All sewers over 5½-ft. diameter are of the familiar horseshoe section, or of a semi-elliptical shape. The largest section of horseshoe type on the work is near the river end of the Southern Outfall, where the section measures 15½ ft. on the springing line by 15 ft. 2 ins. high.

Various types of cross-sections have been adopted to meet the several conditions and difficulties encountered. Among these are the circular and horseshoe types and a type here termed semi-elliptical. As illustrating the general relations of vertical and horizontal internal diameters, which relation is varied to suit the conditions of the individual cases, Figs. 2 and 3 are given. Fig. 2 shows a section of the horseshoe type as used on the Southern Outfall, while Fig. 3 shows a semi-elliptical section.

The semi-elliptical type is intended to be so proportioned that little or no dependence is put upon the resistance of the banks of the trench or backfill upon the haunches of the arch. The hydraulic elements of the two types are very nearly alike and the advantages in this respect of one over the other are so small as to be negligible.

For sewers up to and including 22 ins. in diameter, extra heavy vitrified pipe is used, and from 24 ins. to 66 ins. diameter, an unreinforced monolithic concrete section.

In computing the carrying capacity of these concrete sewers, Kutter's formula, with $n = .013$ has been used. It is probable that actual experiments will show $n = .011$, or perhaps a still smaller quantity, as particular care has been taken to secure a smooth interior surface. The inverts of all the larger sewers are being given a "sidewalk finish."

JUNCTION CHAMBERS.—Particular pains have been taken to have all junctions so designed as to produce as little disturbance in the flow as possible. There are ten or twelve on the entire work as planned, some of them much more complicated than the one shown in detail by Fig. 4, which has been selected as a typical example.

NORTHEASTERN SANITARY TRUNK SEWER.—This is one of the most interesting pieces of work now under construction, combining as it does, sewer and drain in one structure, but with grades running in opposite directions; a long inverted siphon and the usual chambers belonging to it.

The Northeastern Sewer will carry sewage from Crescent Hill and Clifton, growing residential districts now practically without sewerage facilities, while the drain will dispose of the drainage from a portion of the city below the level of the Ohio at flood-season.

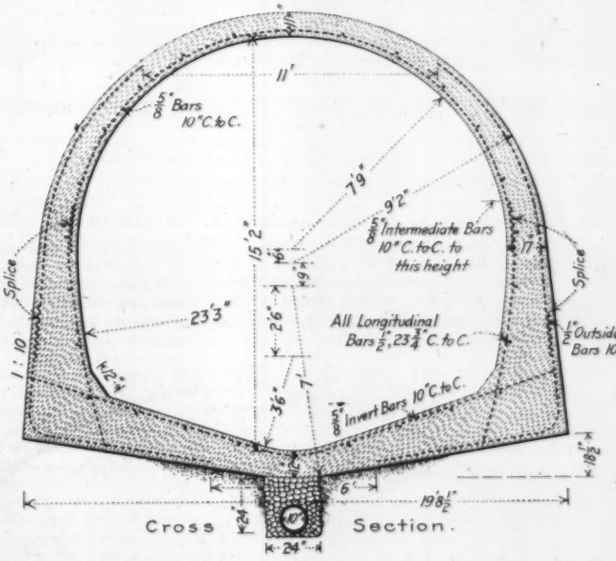
Fig. 5 shows sections of the combined portion. Inlets to the sewer and also to the drain are left at every street. As there is a season every year when the Ohio River is considerably higher than the surface of the "Cut-off," it was necessary to provide a watertight manhole for use on the sewer which is then under pressure. A large manhole casting was found at a local foundry which had originally been designed for use on a kier. This casting was riveted to a ½-in. steel plate diaphragm, stiffened with four knee-braces and the whole built into the concrete masonry of the manhole. No such provision is necessary on the manholes to the drain, as the culvert at the Cut-off Road through which it discharges will be equipped with tide-gates.

Throughout its entire length this combined structure is supported on wood piles. The line of sewer alone is also on piles, in this case of concrete, molded and driven.

34TH STREET OUTLET.—This is the first work of this nature of repairs that the commission has undertaken. The present outlet of this sewer (11½ ft. in diameter) is an 8-ft. boiler-iron conduit. This is in very bad shape, being much flattened by the fill over it, as well as distorted longitudinally. When the distortion was first noticed, a line of posts was placed along the center of the pipe to support the arch, and these form a dangerous obstruction to the flow of sewage through the outlet. Then, too, the outlet is so high that it is entirely out of water for a large part of the summer.

It was, therefore, determined to build a new outlet, at a lower elevation and about 110 ft. farther into the river. This will be entirely submerged at all times when the projects of the government of a 9-ft. stage from Cairo to Pittsburg are realized.

STORM AND SANITARY SEWERS IN THE SAME TRENCH.—The separate system of sewerage has been adopted for the eastern portion of the city, as it is necessary to keep sanitary sewage out of Beargrass Creek, into which all this portion drains. On the laterals, both sewer and drain are laid in the same trench. The sewer is



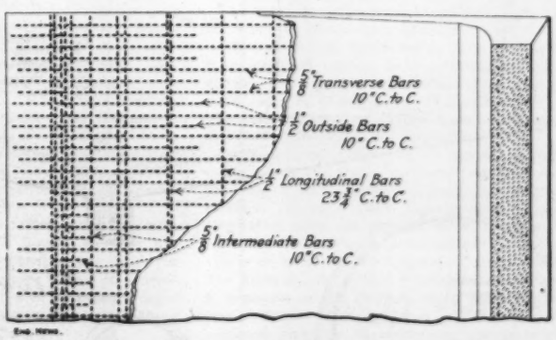


FIG. 2. TYPICAL HORSESHOE SECTION OF REINFORCED CONCRETE USED IN SEWERS OF LOUISVILLE, KY.

*Draftsman, Louisville Sewerage Commissioners, Louisville, Ky.

enough lower than the drain, so that house connections may easily be made under the latter. At curves, it has been necessary to design the manholes with considerable care to avoid interference, and occasionally a single manhole has been made to serve for both sewer and drain. Joints in the sewer, which is invariably of deep-and-wide-socket pipe, are made with sulphur and sand. Thus far there has been no difficulty in

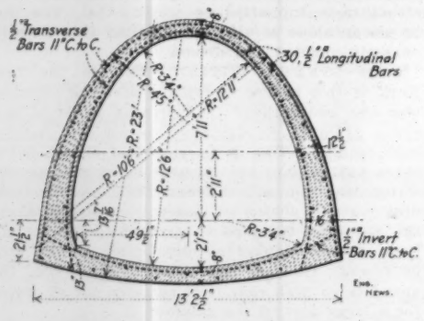


Fig. 3. Typical Semi-Elliptical Section of Reinforced-Concrete Sewer, Louisville, Ky.

the construction of this type of combined sewer and drain. They require careful and constant supervision on the part of the inspector, however.

FIRE CISTERNS.—Louisville is provided with a large number of fire cisterns connected to the city water mains, usually by a 6-in. pipe and gate. They are of two types—known locally as "barrel cisterns" and "jug cisterns." The barrel cistern is a horizontal cylinder 8 to 10 ft. in diameter, with a capacity of from 10,000 to 15,000 gals., and usually having two 20½-in. manholes for engine suctions. The jug cisterns are vertical cylinders of varying diameter and capacity, and having a dome roof. Both types are built of brick.

It has been necessary to destroy a number of these in the work of sewer construction, and they are replaced by cisterns of concrete, in adjacent locations, also of two types, jug and barrel. In some cases it has been possible to use the forms built for the sewer itself for the cistern of the barrel type, but in the cases where the jug type had to be built, owing to lack of room, special forms were constructed.

The principal desideratum in these structures is water tightness. To secure it, it is specified that the sand for the concrete shall contain 10% of fine molding sand, and that joints between old and new work shall have imbedded in them a mild steel plate 18 x 3/16-in. the full length of joint. When spliced, these plates are lapped at least 18 ins. This method of construction has been successful, in securing the result aimed at. One 5,000-gal. cistern was tested by filling into the manholes. At the end of 24 hours the leakage amounted to between 1 and 2 gals., an inappreciable amount.

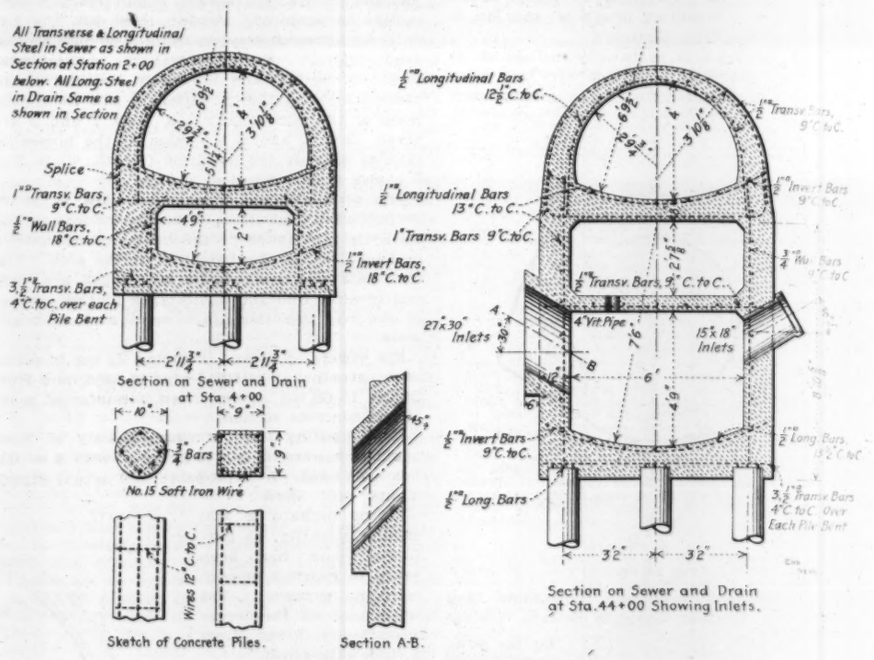

All Transverse & Longitudinal Steel in Sewer as shown in Section at Station 2+00 below. All Long. Steel in Drain Same as shown in Section
Splice
1" Transv. Bars, 9" C. to C.
½" Wall Bars, 18" C. to C.
3½" Transv. Bars, 4" C. to C. over each Pile Bent
½" Invert Bars, 18" C. to C.
Section on Sewer and Drain at Sta. 4+00
¾" Bars
No. 15 Soft Iron Wire
Wires 12" C. to C.
Sketch of Concrete Piles.
Section A-B.
½" Longitudinal Bars 12½" C. to C.
½" Longitudinal Bars 13" C. to C.
1" Transv. Bars 9" C. to C.
27"x30" Inlets
4" Vit. Pipe
15"x18" Inlets
½" Invert Bars 9" C. to C.
½" Long. Bars
Section on Sewer and Drain at Sta. 44+00 Showing Inlets.

FIG. 5. COMBINED SEWER AND DRAIN, LOUISVILLE, KY.

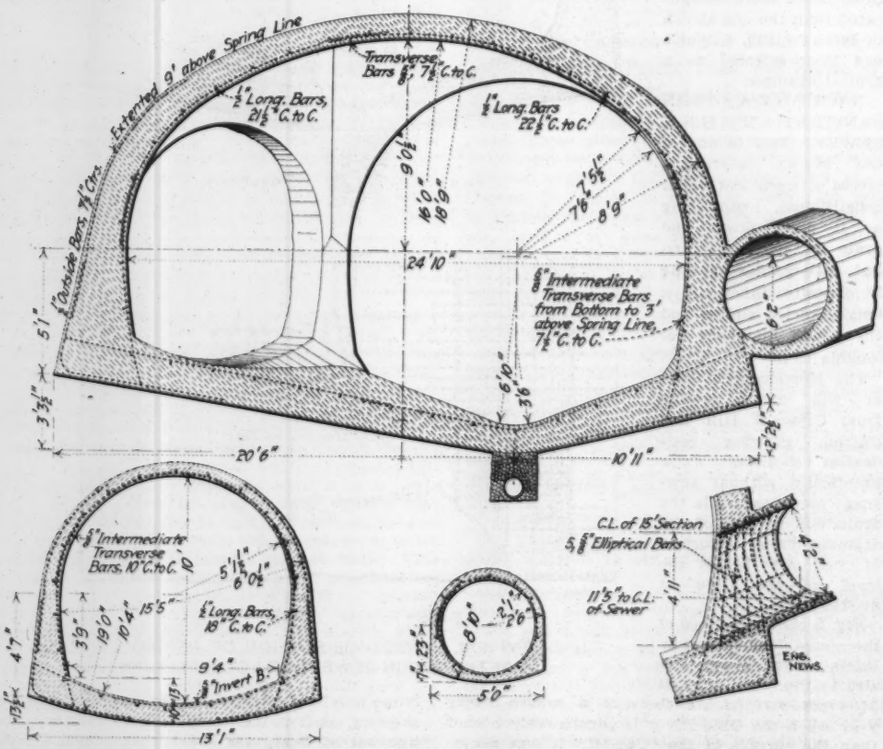

Extended 9' above Spring Line
Transverse Bars ⅝" 7½" C. to C.
1" Long. Bars, 21½" C. to C.
⅝" Long. Bars 22½" C. to C.
⅝" Outside Bars 7½" C.
24'10"
⅝" Intermediate Transverse Bars from Bottom to 3' above Spring Line, 7½" C. to C.
20'6"
10'11"
⅝" Intermediate Transverse Bars, 10" C. to C.
½" Long. Bars, 18" C. to C.
9'4"
⅝" Invert B.
13'1"
C.L. of 15' Section
⅝" Elliptical Bars
11'5" to C.L. of Sewer
5'0"
ENG. NEWS.

FIG. 4. TYPICAL JUNCTION CHAMBER, REIN FORCED-CONCRETE SEWERS, LOUISVILLE, KY.

State Control of Public Water Supplies.*

By PAUL HANSEN,† Assoc. M. Am. Soc. C. E.

It is generally conceded that the state should be given control over the maintenance of the purity of streams, especially so far as this matter affects public water supplies, manifestly because such control cannot always be maintained by municipalities and the only redress which riparian owners can have, whether these be private persons or municipalities, is through long and often fruitless litigation, yet every municipal government should be held strictly responsible for the purity of its public water supply. By a somewhat similar line of reasoning, it would seem that the control of dairies also should be relegated to the state, since many cities secure a large portion of their milk supplies far from without their borders, thus making supervision of the dairies impracticable if not impossible. Again, milk, like water, is frequently a carrier of disease germs, and in communities where the dairy business is not adequately controlled visitors from other parts of the state are liable to infection. Notwithstanding all this, the regulation and control of dairies is practically always left to the municipalities.

There can be no question as to the advisability of state control of at least the sanitary quality of municipal water supplies, for not only does a water supply have a relation to the health of those living in the community, but it also has a relation to the health of many persons who visit the community from other parts of the state and from outside the boundaries of the state altogether. Thus a polluted water supply may constitute a nucleus for the dissemination of typhoid fever and possibly other water-borne diseases throughout a very wide area.

What is the proper state body with which to intrust the duty of controlling water supplies? Practice varies in different states; in a few the duty is intrusted to water and sewerage boards, but in most states it is delegated to state health departments. In any case, the body should be composed of men qualified by training and experience to consider questions that come before it entirely on their merits. To this end the members of the body should be appointed (preferably by the governor) and not elected. The number of members should be large enough and their term of office long enough to prevent interference with the policy of the board by sudden changes in politics.

It is of course not possible for the board to work out all the technical details of the problems that are brought before it, and to this end there must be maintained an engineering department and laboratories.

A law should exist requiring the approval of the state authorities to the sanitary aspects of all public water supplies before construction is begun, with power to hold local officials personally responsible under penalty for the carrying out of the conditions of approval of the supply.

*From a paper read at the Annual Meeting of the Central States Water Works Association.

†Acting Chief Engineer, Ohio State Board of Health, Columbus, O.

Ohio has a law giving the state board of health control over the installation of water supplies and over additions and changes in water supplies, but no specific penalties are provided should the local officials refuse to carry out the orders of the board. While but little trouble has actually arisen from this shortcoming in the law, yet there are a few instances in which the orders of the state board have not been entirely followed. In all such cases, rather than enter into litigation, the effect of which would be problematical, the board has managed to effect compromises whereby the health of the community has been safeguarded but at the expense of constant vigilance on the part of the board.

In addition to authority such as above described, the state board or commission should have authority over existing water supplies in order that these may be brought up to modern standards of purity. Also the state board should have some form of supervision over the operation of water supplies so far as this may effect their sanitary quality. Such supervision would relate with special force to the operation of water purification plants.

Ohio is the only state in the Union which has a law covering just these points; namely, the law commonly known as the Bense Act, passed April 7, 1908, and entitled "an act to authorize the state board of health to require the purification of sewage and public water supplies and to protect streams against pollution." This law has been made really effective by provisions which first enable the state board to hold local officials personally responsible under penalty, and further enable the state board to authorize the issuance of bonds to the extent of 50% of the assessed valuation in excess of the limit previously prescribed by law. The law carries another commendable clause in which provision is made to prevent arbitrary action on the part of the state board of health. After the board has completed its investigations relative to any water supply under the law and has formulated an order intended to correct matters, a hearing must be given the water company or the city officials having charge of the water-works to show reason why the order of the board should not be carried out. If the board after a conference remains of its original conviction, then the order is submitted to the attorney-general and governor for indorsement.

Should the interested parties still not be satisfied as to the justness or practicability of the board's order, they may make a final appeal to a commission of three sanitary engineers. Such commission of engineers shall have one member appointed by the state board of health, one by the party affected, and a third selected by the two engineers first appointed. The expenses of the commission must be borne equally by the state board of health and the affected party. The decision of the commission of engineers is final.

In the case of purification plants, the control of the state board of health under the law is more direct, as it should be. It is provided that whenever the state board of health finds on investigation that a water purification works, on account of incompetent supervision or ineffectual operation, is not producing an effluent as pure as might reasonably be obtained from such plant and by reason of which the water supply has become dangerous to health, the state board of health shall issue an order to the proper persons requiring efficient results. Should this order not be complied with before the end of five days, the fact shall be reported to the governor and attorney-general and upon their consent the state board may order the municipality or water company to appoint and pay the salary of a competent operator to be satisfactory to the state board of health.

The Influence of Waterways on Railways in Great Britain and in India.*

By G. R. JEBB,† M. Inst. C. E.

GREAT BRITAIN.—The influence of waterways, considered as feeders, on railways is negligible, except in the case of the Birmingham Canal Navigations, which system is of an exceptional character. The system is a network of canals chiefly in the mining districts of South Staffordshire. The total length is about 159 miles, exclusive of some 550 private basins and short branches. The canal company does not act as a carrier.

Iron works, mills, forges, brick works, collieries, chain and anchor works, nail works, tube works, galvanizing works, chemical works, etc., have been built from time to time on the banks of the canal and these works form almost a continuous line for many miles. A large number of seams of coal are being worked under and near the canal (one of them 30 ft. in thickness), in consequence of which the canal and works often subside from 15 to 20 ft., and in some places as much as 30 ft.

A large number of the works along the canal have no direct railway communication, in consequence of which 26 railway basins, or places for the direct transshipment of goods between canal boats and railway cars have been made. These basins are of great advantage to the railways. In many cases, the railways have made private lines to the basins and have constructed warehouses, sheds, cranes, etc., for the accommodation of traffic.

The Birmingham Canal may be considered as a valuable feeder to the railways; it is also a competitor, but chiefly for short distances and for the conveyance of coal and bricks. The total amount of traffic interchanged between the railways and the canal averages about 1,202,400 tons per annum.

The annual traffic on the canal is roughly 8,000,000 tons or about 20% of the total traffic of all inland navigations of the United Kingdom. Of this traffic about half is coal, about 80% of which goes to works on the banks of the canal, an average distance of 8 miles.

Of the 41 railway companies in the united kingdom, about one sixth have inland waterways to compete with for traffic.

There are 177 canal systems in the united kingdom representing a length of about 4,673 miles; of these, 46 (1,114 miles) are either owned, or more or less controlled, by railway companies.

All the railway companies whose opinion has been asked are agreed that, speaking generally, a regular and efficient service is maintained on the waterways, but of course the service is dependent on the traffic. The service on the waterways is liable to interruption by frost and drought, and on some of the canals this interruption is considerable.

The railways have to fix their rates with regard to the competition by the various waterways, and carriers on the canals get as near the railway rates as they can between competitive points. Generally speaking, the rates by canal are lower than by railway; in some cases there are agreed differentials.

On the majority of the railways, both collected and delivered and also station-to-station rates are in operation, which include the services of loading and unloading. The rates for mineral class traffic such as coal, bricks, lime, limestone, etc., are exclusive of these services as well as cartage.

Canal companies and private carriers on canals in fixing their charges take into account the classification applicable to all canal companies. For heavy traffic, they quote exceptional rates according to circumstances.

Rates by canal are quoted both exclusive and inclusive of loading and unloading according to circumstances and nature of traffic; they also include, if required, storage accommodation at terminal points. Rates are also quoted at owner's risk, as well as at carrier's risk. In some cases, carriers undertake the collection and delivery of traffic and quote inclusive rates for such services.

The greatest load which can be carried in a vessel navigating waterways (with the exception of the Manchester ship canal) competing with railways is 250 tons and the smallest 18 tons, but on the bulk of the canals the greatest load may be taken as 25 tons. The motive power used is horse haulage on most of the narrow canals, and steam on the wider canals. Experiments with a view to the adoption of more economical and efficient methods of traction have been conducted on the Birmingham Canal by arranging trains of ten compartment boats, each boat carrying about 12 tons and towed by a steam tug. Although the cost was found to be considerably less then by horse traction, the obstruction caused at the bends in the canal and at the locks and bridges was so great that this mode of haulage was not adopted. This method is working satisfactorily on the Aire & Calder Canal, where all the circumstances are specially favorable for its use.

Waterways compete for most descriptions of traffic which are usually conveyed on the railways, but the main competition is in such materials as coal, iron, bricks, timber, grain and manure. The canals are equipped with warehouses, cranes, etc., sufficient to meet the requirements of the traffic; such accommodation in the majority of cases is provided by the canal companies, but in some instances, private canal carriers provide their own warehouses and appliances. The canals are used for the conveyance of agricultural produce only to a very small extent.

Practically in all cases where the railways compete with the canals, goods collected by the former one day are conveyed and delivered at their destination the following day. By canal, except for very short distances, transit takes two or more days. Crane power or manual labor are the usual methods of transshipment between railway and waterway.

Practically all the railways are affected by sea competition, as traffic is conveyed between all ports by coasting services.

Speaking generally, the influence of waterways, both as competitors and feeders to railways, is not so great as it was 30 or 40 years ago, except in the case of the Manchester ship canal. Since those times, railway rates generally have been lowered, particularly in regard to commodities which would be likely to pass by a water route. The railways also give greater facilities for the conveyance of traffic than was the case many years ago, when the competition with canals was much keener than it is to-day.

It is probable that if waterways were enlarged and improved, and more efficient service was given, this might lead to some reductions in railway rates between points for specific traffic, but this would depend entirely on the extent of the enlargement and improvement.

The Manchester ship canal (which is in a class of its own) was opened Jan. 1, 1894, and is 35½ miles in length. The bottom width is 170 ft. for five miles from Manchester, and then 120 ft. The width at water level varies, but is about 250 ft. for five miles, and then 200 ft. The depth of water is 28 ft. Docks, quays and warehouses have been constructed in Manchester for the accommodation of the largest cargo-carrying vessels.

The effect of this canal as a competitor with the railways is that ocean traffic which would have been landed at Liverpool and its adjacent ports (giving the railways the transportation to Manchester and other towns) is now delivered at Manchester by ocean-going vessels. The canal is also in competition with certain railway routes. It feeds the railways through Manchester Docks in respect of traffic for inland towns, but the railways get less mileage than before the canal was made.

Sea freights from Manchester Docks are invariably the same as to Liverpool, but when landed at the latter port, dock and town dues are levied in addition to the sea and rail freights. The canal company cuts its tolls and other charges, so that the total expense through Manchester Docks is never more than if the traffic had been conveyed by way of Liverpool, while in the majority of cases, the expense is less.

A royal commission on canals and waterways is taking evidence on the following subjects:

1. The present condition and financial position of canals and waterways. (2) The causes which have operated to prevent the carrying out of improvements by private enterprise, and whether such causes are removable by legislation. (3) Facilities, improvements and extensions desirable in order to complete a through communication by water between centers of commercial, industrial, or agricultural importance, and between such centers and the sea. (4) The prospect of benefit to trade of the country compatible with a return on the probable cost. (5) The expediency of canals being made or acquired by public bodies or trusts, and the methods by which funds for the purpose could be obtained or secured; and what should be the system of control and management of such bodies or trusts.

Representatives of various trades and public authorities have given evidence advocating the making of four new main canals from the Midlands near Birmingham to the sea at the mouths of the rivers Mersey, Severn, Thames and Humber. But however much the witnesses differed in advocating these canals, all agreed that the public could not be depended upon to find the money for such improvements without a guarantee either from the state, or from county or borough councils. It is clear from the evidence that the object of most of the witnesses was merely to use the improved waterways in an endeavor to bring down railway rates. Should these four canals be made, I feel sure that no fair return on the capital expended would be possible.

INDIA.—Of the nine main railway companies, all have to compete (more or less) with river navigation and sea service. Competition between railways and waterways is increasing, with a few exceptions.

Except in the dry season, there is a regular and efficient service maintained by the waterways. Railway rates, in the majority of cases, have to be adjusted to meet the competition by water, and only where the time occupied in transit is of no importance is traffic carried by waterways.

The rates by railway and waterway are by no means the same, as the steamer companies have quite a separate tariff and charge accordingly. The steamer companies' rates are not subject to any statutory control, as the railway rates are, by a schedule of maximum and minimum rates to be charged, which is fixed by government. The rates charged by the steamer companies are invariably lower than the railway rates.

In most cases, there is an agreed classification and tariff among the water carriers; freight charges are also fixed by agreement between the owners of goods and the carriers. In some cases, the rates are at carrier's risk; alternative rates are also quoted at owner's risk and are inclusive of loading and unloading and cover the provision of terminal accommodation for a specified period. The general rule is that traffic for conveyance by water is tendered at and removed from the water carrier's depots.

Special bargains or reductions are made in the rates by the water carrying companies for large quantities, but speaking generally, the same rates are charged to all parties alike. The loads carried vary with the different description of boats, from 2 to 40 tons on the river Indus, from 1½ to 6 tons on the Tuleli Canal and up to 1,000 tons by steamers plying on the rivers Ganges and Bhagirathi.

The classes of traffic chiefly competed for by the waterways is salt, betel nut, spices, sulphur, glass, agricultural produce and other miscellaneous articles, but when the water rises in the rivers they carry grain and seeds in

*Abstract of a paper prepared for the 1910 meeting of the International Railway Congress, and published in the August "Bulletin" of the International Railway Congress Association.

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large quantities. Only in a few cases do the steamer companies provide warehouses and cranes.

On a route of 265 miles, the time by rail is three days, while the time by steamer is 6 days in the rainy season or 10 to 13 days in the dry season. On two routes of 330 and 344 miles, the time by rail is four days, while by steamer it is 8 days in the rainy season and from 13 to 15 days in the dry season.

On the Ganges and Bhagirathi rivers, cargoes are dealt with in flats (or flat boats) which are used as floating warehouses. These flats are dropped by the steamers at the different depots and remain there often for several days until they are loaded. Some of the larger steamers carry cargo on their lower decks, in which case the steamers have to stay at the depot until the cargo is loaded or unloaded.

To a certain extent the waterways act as feeders to the railways in all classes of goods but chiefly grain and seed. Traffic is not exchanged between railway and waterway as part of a through route, but in cases where special arrangements are made with the water carriers for combined carriage, traffic is carried through at the combined agreed rates.

Transshipment is performed mostly by manual labor, crane power being provided in a few cases.

Railway traffic is affected by sea competition to no appreciable extent.

The waterways interfere only to a slight extent with the earnings of the railways, as although they have taken away some traffic from them, they have brought traffic which the railways would not have had but for the waterways. It is generally considered that if the waterways were enlarged and improved, considerably more traffic would be diverted from the railways than at present.

Annual Meeting of the Street and Interurban Railway Association.

The annual meeting of this association and of its four affiliated associations (engineering, accountants, claim agents, and traffic officers) was held at Denver, Colo., Oct. 4 to 8, with an attendance of over 2,500 members and guests. Owing to the long distance and the large number of persons attending, it was possible to make special transportation arrangements in many cases, and special trains were run from New York, Boston, Chicago, St. Louis, etc.; this contributed greatly to the comfort and pleasure of the parties, and promoted sociability and general acquaintanceship. The weather was favorable throughout the convention, and elaborate arrangements were made by the local authorities for the pleasure and convenience of the visitors. The official badge served as a pass on all street and interurban cars for the entire week of the convention, and as the number of members and guests was over 2,500 the extent of this practical hospitality may be realized.

Of entertainment there was abundance, including "seeing Denver," trips for the ladies, theater parties and a barbecue at the White City, a pleasure resort owned by the Denver Tramway Co. A special party of hunters had provided bear, elk, deer and smaller game, which were cooked on the grounds for the edification of the visitors. All the "shows" were open free, and this entertainment was highly appreciated. On Friday, Oct. 8, special trains on the Denver, Northwestern & Pacific Ry. took nearly all the party to the summit of the line of Corona, 11,660 ft. above sea level, or 6,460 ft. above Denver. The line reaches this summit by a most interesting development of grades and curves, including long grades of 4%. Lunch was provided on the trains. Other side trips to Colorado Springs, Pike's Peak, the Cripple Creek district, etc., were arranged for smaller parties.

The meetings were held in the new Auditorium, a new steel and concrete building erected purposely for the accommodation of conventions, and as the several auxiliary associations are quite distinct in character, there was no difficulty in arranging the program with simultaneous meetings of different sections. The exhibition of machinery, equipment and supplies was also held in the Auditorium and an annex. This formed an important auxiliary of the convention, and was both extensive and comprehensive, ranking with those at the conventions of the Master Car Builders and Railway Engineering associations. The adoption of a general scheme of decoration and of rules as to uniformity in size and style of the signs (with a prohibition of large signs obstructing the view) helped materially in adding to the dignity of the exhibition as a whole, and to the effectiveness of the individual displays.

American Street and Interurban Railway Association.

The first meeting of the main or parent association was held in the afternoon of Oct. 4, the chair being occupied by the President, Mr. James F. Shaw (Boston), Chairman of the Board of Directors of the Boston & Worcester Electric Co. He introduced Mr. Wm. G. Evans, President of the Denver City Tramway Co., who made a brief address of welcome on behalf of the local committee. The executive committee appointed a special committee to consider and report upon matters relative to the general policy of the work of the association.

The report of the Secretary and Treasurer, Mr. B. V. Swenson (New York) was presented and approved. This showed 304 active members (companies) and 808 associate members (individuals), and a cash balance of $10,194. At the meeting of 1908, a committee was appointed to consider some suggestions of the (then) President, Mr. Goodrich, in regard to a separation of the meetings of the main and affiliated associations. Mr. Shaw, as chairman of this committee, presented a report which recommended that no change be made in the present practice of holding the annual meetings at the same time and place as that of the main association, but that an additional winter meeting shall be held by the latter during the winter to consider (in executive session) any matters of pressing interest and report to the executive committee.

The annual presidential address, delivered by Mr. James F. Shaw, showed that this country has about 1,250 operating street and interurban railways, with 35,000 miles of single track and 75,000 passenger cars. The number of passengers carried per year is about 10,000,000,000, and the gross annual income is $440,000,000. There are about 225,000 salaried employees and wage earners, who receive about $150,000,000 annually. The industry has recovered generally from the effects of the panic of 1907, and the present aspect of the business situation indicates the development of electric railway construction on an extensive scale in all parts of the country. An important movement, which originated in Massachusetts, is that for the adoption of needed increases in rates of fare, especially in view of the great improvement in service and the establishment of transfers. This applies both to urban and interurban lines, and calls for a more scientific basis of rates. The corporation tax under the new tariff law of 1909 puts an additional tax on this business, and is regarded by Mr. Shaw as unjust to the corporations and the owners of capital stock. The present conditions may be improved in either one of these ways: (1) by increasing fares; (2) by reducing the distances for which passengers are carried under the present fares; (3) by relieving the companies from certain forms of taxation and state or municipal requirements.

Public service commissions are now active in New York and Wisconsin, and reasonable public regulation on the part of the state may produce conditions which will prevent repetition of the disgraceful contests which political agitators have been able to wage in some of the larger cities during the past few years, notably in Chicago and Cleveland. To be effective, permanently, regulation of this character must safeguard the interests of the corporation and its employees as effectively as it protects those of the traveling public.

No important trunk line railways have changed to electricity this year any portion of their suburban systems for which plans had not been made previously, but the officers of those companies which are now using electric power have expressed themselves as well satisfied with the service rendered. A new type of electric locomotive, differing from any used on the other trunk lines, has been developed by the Pennsylvania Ry. tunnels at New York. Several of the railway companies in the central and far western states are carefully considering the adoption of electric power for certain sections of their lines.

A paper on "Organization, from the Standpoint of the Smaller Companies," was read by Mr. Ernost Gonzenbach, President and General Manager of the Sheyboygan (Wis.) Electric Railway, Light & Power Co. His purpose was to show that the "one-man" system is not economical, even for a small company; there should be a system of organization, which will provide for the proper carrying on of the business in the event of the absence of any individual due to sickness or other cause. He advocated the study of military organization in its relation to work of this kind.

The other two meetings of the association were held in executive session, for the consideration of reports and papers. The officers were all reelected, except the Secretary (Mr. B. V. Swenson) who has resigned, and whose successor will be appointed by the Executive Committee. The President is Mr. James F. Shaw, Chairman of the Board of Directors of the Boston & Worcester Electric Co. The Vice-Presidents are as follows: Arthur W. Brady, President of the Indiana Traction Co., Anderson, Ind.; Thomas N. McCarter, President of the Public Service Ry. Co., Newark, N. J.; Geo. H. Harris, Second Vice-President of the Washington (D. C.) Electric Ry. Co.; and Charles N. Black, Vice-President and General Manager of the United Railways of San Francisco.

Auxiliary Associations.

The Traffic and Transportation Association devoted a considerable part of its time to the discussion of codes of rules and regulations governing operation on street and interurban railways, following closely upon the code of the American Railway Association. Some interurban roads are already operating entirely under this latter code. Another subject for discussion was the handling of express and freight traffic, and interesting particulars were given of the operation of this class of service on some interurban roads.

The Accountants Association discussed, among other matters, the basis of operating statistics for interurban railways. One matter in dispute was whether the mileage should be "revenue" or "total" car mileage, and about 66% of those present used or favored the latter, which includes dead mileage. As a unit of earnings, the revenue mileage must be used, but for operating expenses and such matters as life of wheels and cost of lubrication, etc., the total mileage must be used. A committee recommended the general use of the standard classification of accounts prepared after conference with the Interstate Commerce Commission and state railway commissions.

The Claim Agents Association met in executive session to consider reports relative to damage suits, and the relation of the claim department to the medical and operating departments.

American Street and Interurban Railway Engineering Association.

At the first meeting on Oct. 5, the annual address was read by Mr. Paul Winsor, Chief Engineer of Motive Power of the Boston Elevated Ry. In this he pointed out that all the work of the past has been done by standing committees. The report of the Committee on Way and Track was then presented, and its discussion occupied the entire remaining time of the session. An abstract of the report and discussion will be published separately.

At the morning meeting on Oct. 6, the report of the Committee on Equipment was presented. This consisted mainly of a series of individual papers or reports on a number of subjects, and abstracts of some of these we shall publish separately. The committee had proposed to change the present standard form of wheel flange to that of the M. C. B. standard, which would cut away the flange very slightly on the inner side but thicken it to a greater extent at the back. This recommendation, however, was objected to, and was struck out. At the afternoon session the discussion was continued, and the report of the Committee on Power Generation was discussed.

At the closing meetings on Oct. 7, the report of the Committee on Standards was presented. One of the subjects which had been assigned to this committee dealt with standard gears, pinions and gear ratios, but the report stated that it seemed impracticable at this time to recommend standards in this direction. Specifications were submitted for wrought-iron bars and wrought-iron and steel axles, and the use of the Railway Signal Association's specifications for rubber-covered wire was recommended. Mr. W.

G. Gove, Superintendent of Equipment of the Brooklyn Rapid Transit Co., described the system of standardization introduced on his road, and the excellent results that have been obtained. On the part of the Westinghouse and General Electric companies a complaint was made that the railways do not adopt or adhere to the standards officially adopted by the Association. While the manufacturers have adopted these as their own standards, it is found that the railway officers require variations in certain details. The committee proposes that the standards shall be considered by officers of different departments (such as both motive-power and track officers in considering wheel standards), and that their adoption shall be by letter ballot instead of by vote of the association. While this would make it less easy to secure the adoption of any particular standard, it would make the adoption more effective.

The report of the Committee on Power Distribution presented requirements for feeder lines, conductors, etc., and some parts of this we shall publish separately.

The election of officers of this association resulted as follows: President, F. H. Lincoln, Assistant General Manager of the Philadelphia Rapid Transit Co.; Vice-Presidents, W. J. Harvie (Chief Engineer of the Utica & Mohawk Valley Ry.), Syracuse, N. Y.; E. O. Ackerman (Engineer of Maintenance of Way, Columbus Railway & Light Co.), Columbus, O.; J. S. Doyle (Superintendent of Car Equipment, Interborough Rapid Transit Co.), New York; Secretary and Treasurer, John W. Corning, Electrical Engineer of the Boston Elevated Ry., Boston, Mass.

A PASSENGER TRAIN WAS DERAILED on the Gulf, Colorado & Santa Fe Ry., Oct. 6, at Heidenheimer, Tex. Four persons were killed and 30 others injured. The accident is ascribed to a defective rail.

GASOLINE IN THE SEWERS is assigned as the cause for a series of explosions which took place Oct. 7 in New York City in the district between 42d and 53d Sts., from Ninth Ave. to the Hudson River. About eighty or one hundred manhole covers were blown to a height of many feet and caused considerable damage to property in falling. The explosion is attributed to gasoline run into the sewers from automobile garages. High tides on the afternoon of the accident prevented the gasoline from flowing into the river.

A HURRICANE STRUCK KEY WEST, FLA., Oct. 11, and caused heavy damage to buildings in that city and to vessels in the harbor. Reports state that the wind maintained a velocity of 80 mi. per hr. for six hours. Only one death due to the storm has been reported. Five hundred buildings were leveled and sixty or seventy boats, including three vessels of considerable size, were either sunk or driven ashore. The damage to property at Key West is estimated at $2,000,000.

A WORK TRAIN COLLIDED WITH A FREIGHT on the Atchison, Topeka & Santa Fe Ry., Oct. 8, on the outskirts of Topeka, Kan., and 17 men were killed. The work train, consisting of four flat cars, on which were fifty laborers, was backing into the city and was struck by the outbound freight train on a curve. Reports state that the crew of the work train had disregarded train orders.

ANOTHER VIADUCT DYNAMITING outrage occurred on Oct. 7. A bridge being built over the tracks of the New York Central & Hudson River Ry. at Michigan and Elk Sts., Buffalo, N. Y., was damaged. A previous attempt to destroy this structure had been made a month before, but the second one was more successful, the damage being several thousand dollars, according to unofficial accounts. Several neighboring buildings were injured by fragments. No persons were hurt, fortunately. It is said that no less than four bridge dynamitings have been perpetrated in Buffalo during the past year, all of them involving structures under erection by contractors who employ non-union labor.

STREET RAILWAY ACCIDENTS in Chicago during the month of September, according to figures prepared in the office of the city attorney, caused the death of 17 persons and injured 395 others. In August ten persons were killed in Chicago by street railway accidents.

PANAMA CANAL EXCAVATION during September totaled 2,836,385 cu. yds., a daily average of 113,455 cu. yds. for the 25 working days, as against 2,755,178 cu. yds., a daily average of 105,969 cu. yds. for the 26 working days of August. The rainfall in September was 10.07 ins. against 9.28 ins. in August. The amount of concrete laid in September was 21,497 cu. yds. and the amount of fill placed 451,783 cu. yds. against 7,643 and 454,677, respective figures for August.

SAFE RAILWAY OPERATION.—An excellent performance in railway operation was made by the transportation lines in and around New York City during the Hudson-Fulton celebration. The traffic within the city in the week from Sept. 25 to Oct. 2 was beyond all previous figures, and on three or four occasions the subway, elevated railways and street-car lines in Manhattan borough were so congested that nearly the whole police force of the borough was needed to control the packed crowds of passengers and would-be passengers. The maximum day's business of the subway and elevated lines combined was about 2,200,000 passengers, and the figure for 7 days was only a few thousand under 13,000,000. The railways leading into the city handled a heavy excess of traffic throughout the week, and, according to a report in the "Railroad Gazette," on Sept. 25 the Erie, which carries the heaviest commuter traffic regularly, handled (109,000) about 2½ times as many persons as on ordinary days. This entire week of heavy traffic went by without a single train-accident, on either the city lines or the railways.

THE WRIGHT AEROPLANE of the Signal Corps of the U. S. Army, has made several notable record performances recently under the guidance of Mr. Wilbur Wright. On Oct. 9, he covered a closed course of about 4,000 ft. in 58⅘ seconds, a rate of about 46.6 mi. per hr.

On Oct. 11, experiments were made in flying in circles of minimum diameter. A complete circle having a radius of about 270 ft. was cut in 17⅘ seconds. To show that this was not phenomenal the trick was repeated in 19½ seconds.

Starts were made without the use of falling weights to give the flyer its initial velocity before rising.

THE INTERNATIONAL BALLOON RACE for the Gordon Bennett cup was won by Mr. E. W. Mix, of Columbus, Ohio, who covered a distance of 683 miles from Zurich, Switzerland to a point slightly north of Warsaw, Russian Poland. He used the balloon "America II.," made in Paris a year ago for the American contestants in the international race from Berlin. Mr. Mix was siezed on his descent by the Russian police and confined.

The Frenchman Le Blanc and Capt. Messner, representing Switzerland, are tied for second place, each having covered about 495 miles. Col. Schaeck, Switzerland, last year's winner, is fourth; Capt. von Abercrom, Germany, is fifth, and De Beauclair, also of Switzerland, is sixth.

AMERICAN BALLOON RACES for the Lahm cup were started from St. Louis, Mo., on Oct. 6. The balloon "St. Louis III.," piloted by Mr. S. L. von Puhl, is reported to have won by a trip of 580 miles to Wahkon, Minn., covering 41 hours 35 min. The five other balloons starting were aloft from 21 to 48 hours and landed variously in Minnesota, Alabama, Missouri and Arkansas.

THE DELAWARE RIVER TUNNEL PROJECT was advanced to a new stage on Oct. 6, when the City Council of Camden, N. J., passed an ordinance authorizing the construction in Camden. The ordinance specifies that stations shall be built near the Pennsylvania R. R. station, at Third St., Haddon Ave., Twelfth St., 27th St. and 36th St. The eastern part of the line is planned to be on elevated structure. The council specified an annual payment of $25,000 by the company to the city. Authority for construction on the Philadelphia side was obtained some months ago. Stern & Silverman, of Philadelphia, who are promoting the enterprise, are quoted by the Philadelphia "Press" as saying that the Camden terms are excessive and prohibitory.

THE LOETSCHBERG TUNNEL IN AUGUST fell below its remarkable figures of July. The advance of the north heading was 915 ft., using four drills, in jurassic oolite; that of the south heading 525 ft., using five drills, in granite, occasionally mixed with quartz porphyry. The aggregate heading length on Sept. 1 was almost exactly half the final length of tunnel (47,649 ft.); the north heading has penetrated 10,115 ft. and the south heading 13,848 ft.

PROGRESS ON THE GATUN DAM.—The surface of the water in the hydraulic fill at Gatun Dam was raised 3 ft. on Aug. 23, and 3 ft. more on Sept. 8. During part of the month of August only one of the 20-in. suction dredges was working on the fill, one of them being at Mount Hope marine shops for repairs, and the other on its way from a position north of the dam to its present position south of the dam.

The placing of dry fill on the toes of the dam with miscellaneous spoil from Mindi, Bohio, Buena Vista, and rock from Culebra Cut, continues. A trestle is being driven on the 30-ft. contour at the south end of the spillway and will be continued across the West Diversion. When the diversion is closed and the water of the Chagres is allowed to run through the spillway, a big dump will be opened there on the upstream toe of the dam. In addition to spoil from nearby work, miscellaneous excavation will be taken from Culebra Cut, and it is expected that as many as twelve trains will be delivered daily from there.—"Canal Record," Sept. 29.

TESTS ON CONCRETE IN SEA-WATER, being carried on by the Aberthaw Construction Co. and reported in Engineering News, Dec. 24, 1908, p. 730, have now been in progress somewhat over six months. The report made on this six-month exposure is as follows:

Although the specimens had been exposed to freezing temperature during several months of the winter, and to the variable conditions of midsummer, examination failed to disclose any visible change in the surface of any of the specimens. It is independently stated by the cement chemist that all cements are behaving in a perfectly normal manner and the tests to date appear to be perfectly satisfactory. It is thought that a considerable time must elapse before any results will be obtained which will tend to throw any additional light on the effect of the water on concrete, or on the effect of various compositions of cements.

ELECTRIC RAILWAYS OF THE COUNTRY.—The "Electric Railway Journal" of Sept. 4 publishes a table showing mileages, cars and capitalization of the various properties in the United States between July, 1908, and May, 1907, and a similar period of 1907. From this table the following few figures have been arranged:

New England States.	No. of Ry. Cos. 1908.	Track Mileage. 1908.	Electrically Equipped Cars, Sweepers and Locomotives. 1908.	Total Cars. 1908.
Maine	16	495	530	755
New Hampshire	20	295	450	495
Vermont	11	125	130	150
Massachusetts	69	2,980	8,260	10,510
Rhode Island	10	460	1,000	1,200
Connecticut	14	1,035	1,930	2,100
Total	140	5,390	12,300	15,210
Eastern States.				
New York	168	4,720	13,700	17,990
New Jersey	48	1,285	2,825	3,190
Pennsylvania	170	4,210	8,475	9,625
Delaware	4	75	155	171
Dist. of Columbia	8	393	1,015	1,450
Maryland	14	540	1,990	2,175
Virginia	24	470	670	880
West Virginia	24	350	435	470
Total	460	12,063	29,265	35,951
Central States.				
Michigan	28	1,355	1,915	2,415
Ohio	105	4,455	5,100	5,720
Indiana	53	2,320	2,000	2,440
Kentucky	13	380	625	925
Wisconsin	23	790	835	950
Illinois	65	3,015	5,100	7,360
Minnesota	10	560	790	840
Iowa	30	760	880	990
Missouri	27	1,088	2,320	2,710
Total	354	14,723	19,545	24,350
Southern States.				
North Carolina	14	150	185	225
South Carolina	7	140	160	190
Georgia	13	395	570	675
Florida	10	150	175	235
Alabama	11	302	410	600
Mississippi	10	96	155	175
Tennessee	11	360	680	745
Louisiana	8	250	640	700
Arkansas	9	132	193	228
Total	93	1,975	3,168	3,773
Western States.				
North Dakota	3	18	45	50
South Dakota	4	30	8	10
Nebraska	10	240	460	520
Nevada	2	11	10	12
Kansas	17	295	235	330
Oklahoma	15	215	140	170
Texas	29	550	735	865
Colorado	17	472	445	925
Montana	6	81	117	137
New Mexico	2	11	10	11
Idaho	7	145	65	115
Utah	5	166	255	280
Washington	28	900	875	1,900
Oregon	12	390	360	655
California	53	2,530	2,579	3,900
Arizona	4	37	30	37
Wyoming	1	5	5	6
Total	205	6,096	6,374	9,932
United States	1,252	40,247	70,652	89,216
Hawaii, Porto Rico and Philippine Islands & West Indies	11	185	240	380
Canada and Newfoundland	52	1,250	2,800	3,055
Cuba	4	140	326	703

A SIMPLE 40-TON HAND-POWER HOIST is being sold by the Yale & Towne Mfg. Co. It consists of two 20-ton "triplex" blocks (each double) hung at the ends of a double-channel equalizer and carrying a similar equalizer beam on their hooks. Large plate ring-hitches are planned to the centers of the two equalizers, for hanging the hoist and attaching the load. As each half

of both blocks has two hand-chains, eight men can work simultaneously in hoisting the load. Two men working at the chains of one half block raise the load at one-fourth full speed. A single man, therefore, has to exert only twice the pull required of each of eight, though the load is hoisted at only one-fourth the speed. For special work requiring still heavier loads to be hoisted, it is easily possible to connect two such 40-ton hoists by slinging a beam between their lower rings or by hooking to the two ends of the load. The device, being simple, cheap and of low head-room, is useful for work where occasional heavy loads have to be hoisted, and where a bridge crane is not required or too costly for occasional use.

HEALTH CONDITIONS AT PANAMA.—The number of laborers on the rolls on Aug. 1 was larger than at any previous time. The following table shows the number of employees carried on the rolls during the month of August for each year since American occupation:

Aug.	No.	Aug.	No.
1904	6,029	1907	40,443
1905	19,226	1908	44,225
1906	29,555	1909	49,020

Attention is called to the low death rate of the total population, 16.20 per thousand. The rate for August during the previous years was as follows:

Aug.	Rate.	Aug.	Rate.
1905	51.05	1908	26.65
1906	64.12	1909	16.20
1907	33.75		

The death rate for the State of Pennsylvania for 1907 was 16.40, for New Jersey 17.10, and for California 18.60.

The death rate among employees was lower than was recorded during any previous August, as evidenced by the following table:

Aug.	Rate.	Aug.	Rate.
1904	13.93	1907	27.59
1905	10.97	1908	11.39
1906	62.12	1909	10.28

For special diseases the showing is equally satisfactory. In 1904, for malaria, the admission rate was 138 per thousand; 1905, 489 per thousand; 1906, 1,081 per thousand; 1907, 641 per thousand; 1908, 413 per thousand, and 1909, 222 per thousand.

The typhoid fever rate among employees during the month was 25 per 100,000. For Pennsylvania, for the year 1906, the rate was 56 per 100,000, and for 1907, 50 per 100,000. For the registration area of the United States at large, the average rate for 1906 was 31 per 100,000, and for 1907, 29 per 100,000. It will, therefore, be seen that among employees in the Canal Zone the typhoid fever rate is less than one-half of that which prevailed in Pennsylvania, and considerably less than the average for the registration area of the United States.

The best measure of the efficiency of a force is its sick rate. This rate for August, 1909, and for previous years was as follows:

Aug.	Sick every day.	Aug.	Sick every day.
1905	25	1908	25
1906	42	1909	21
1907	29		

The above table shows that as far as the sick rate is concerned, the force was more efficient during August, 1909, than in any previous August.

No cases of yellow fever or bubonic plague occurred on the Isthmus during the month.—From the Report for August of Col. H. F. Hodges, Acting Chairman, Panama Canal Commission, in the "Canal Record," Sept. 22.

Personals.

Mr. M. J. O'Brien, of Montreal, Que., has become President of the Matane & Gaspe Ry., which runs from St. Flavie to Matane, Que., a distance of 40 miles.

Mr. P. J. Colligan, Assistant Master Mechanic of the Chicago, Rock Island & Gulf Ry., at Ft. Worth, Tex., has been made Division Master Mechanic at Dalhart, Tex.

Mr. C. B. Coulson, formerly an assistant engineer of the Oregon Short Line R. R., has become Chief Engineer of the Castle Valley R. R., with headquarters at Price, Utah.

Mr. G. M. Howden, of Alexandria, Va., has been appointed Master Mechanic of the St. Louis-Louisville lines of the Southern Ry. at Princeton, Ind., to succeed Mr. C. M. Hoffman, resigned.

Mr. P. C. Hart, Superintendent of the Chicago, Milwaukee & Puget Sound Ry., at Seattle, Wash., has been made General Manager. Mr. W. B. Foster, of Marion, Iowa, succeeds Mr. Hart as Superintendent at Seattle.

Mr. H. H. Adams, Division Superintendent of the Michigan Central R. R., at St. Thomas, Ont., has been appointed General Manager of the Toronto, Hamilton & Brantford R. R., with headquarters at Hamilton, Ont. Mr. Adams has been succeeded at St. Thomas by Mr. H. Sheaver, whose appointment was noted in our issue of Oct. 7.

Mr. C. E. McMullin, Assistant Superintendent of the Lake Superior division of the Northern Pacific Ry., has been made Superintendent of the Seattle terminal division. Mr. K. M. Nicoles, trainmaster at Duluth, Minn., has been appointed Assistant Division Superintendent to succeed Mr. McMullin.

Mr. Arthur H. Blanchard, M. Am. Soc. C. E., Deputy Engineer of the State Board of Public Roads of Rhode Island and Associate Professor of civil engineering at Brown University, sailed Oct. 13 for a tour of eight months to be devoted to an investigation of the construction and maintenance of bituminous macadam roads in France, England and Scotland.

Mr. Herman F. Hoevel, Member of the Verein Deutscher Ingenieure and of the Verein Deutscher Eisenhüttenleute, has become Vice-President and Secretary of the Wiener Machinery Co., 50 Church St., New York City. Mr. Hoevel is a graduate of the University of Charlottenberg. Before coming to this country he was associated with the Siemens-Schuckert electric works, of Nuremberg and Berlin.

Mr. Walter G. Leininger, one of the engineers of the bureau of streets of Chicago, Ill., has been announced as the successful candidate in a promotional civil service examination for the position of third assistant superintendent of streets. It has been decided that all paving repairs will in future be done by the city instead of being let out to contractors, and Mr. Leininger, in his new position, will have charge of this work. He was graduated at Armour Institute in 1906 and is now 27 years old. His salary will be $3,600.

Mr. Ira W. McConnell, M. Am. Soc. C. E., Supervising Engineer in the Reclamation Service, has resigned to enter private practice. Mr. McConnell graduated in 1897 from Cornell University and was afterward retained as member of the faculty teaching engineering, and having charge of the erection of the civil engineering laboratory there. In 1898 he was employed in the Brooklyn Navy Yard. Later as Superintendent of Construction he built the North Tarrytown, N. Y., sewer system. He was successively employed as Superintendent of Construction on the Indianapolis Water-Works, and the New Orleans Water and Sewer Systems. In 1903 he was one of the faculty of the School of Mines of the University of Missouri.

On April 24, 1903, he was appointed Hydrographer in the U. S. Geological Survey, and on June 24, 1904, was made resident engineer in charge of the Uncompahgre project in Colorado, the principal feature of which is the Gunnison tunnel, the six-mile waterway bringing the waters of this stream to the Uncompahgre Valley. On Nov. 1, 1907, he was promoted to the position of Supervising Engineer in the Reclamation Service in charge of the works of that Bureau in Colorado, Kansas, Nebraska, Oklahoma, southern Wyoming and South Dakota. His most notable work for the Government has been the construction of the Gunnison tunnel, but he has also had charge of the large earth dam near Belle Fourche, South Dakota, one of the most notable structures of its kind in this country. The resignation of Mr. McConnell is a distinct loss to the Reclamation Service.

Obituary.

Sidney B. Cushing, President, General Manager and General Superintendent of the Mill Valley & Mount Tamalpais Scenic Ry., committed suicide Sept. 30 in the grounds of his summer home at Blythedale, Cal. He was born at San Francisco, Cal., in 1857. His suicide is ascribed to despondency over ill-health.

George P. Hilton, M. Am. Soc. C. E., Vice-President of the Hilton Bridge Construction Co., died Oct. 7 at his home in Albany, N. Y., from cerebral hemorrhage. Mr. Hilton was born at Albany, N. Y., in 1859 and graduated at Amherst College in the class of 1881. Upon leaving college, he began to work in the office of the Hilton Bridge Construction Co., of which he became Vice-President in 1892. He was President of the Albany Chamber of Commerce, Vice-President of the Albany Trust Co., Treasurer of the Corning Foundation and Treasurer of the Cathedral of All Saints. For some weeks before his death he had been chairman of the finance committee of the Hudson-Fulton celebration in Albany.

Engineering Societies.

COMING MEETINGS.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct. 19. Annual convention at Jacksonville, Fla. Secy., S. F. Patterson, Boston & Maine R. R., Concord, N. H.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Oct. 19-22. Annual convention at Richmond, Va. Secy., Chas. O. Probst, Columbus, Ohio.

AMERICAN GAS INSTITUTE.
Oct. 20. Annual meeting at Detroit, Mich. Secy., A. B. Beadle, 29 W. 39th St., New York City.

AMERICAN ELECTROCHEMICAL SOCIETY.
Oct. 29-30. Annual meeting at New York City. Secy., Jos. W. Richards, Lehigh University, South Bethlehem, Pa.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Nov. 9-11. Annual convention at Little Rock, Ark. Secy., A. P. Folwell, 239 West 39th St., New York City.

NATIONAL MUNICIPAL LEAGUE.
Nov. 15-19. Annual meeting at Cincinnati, Ohio. Secy., Clinton R. Woodruff, Philadelphia, Pa.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Nov. 16. Annual meeting at Washington, D. C. Secy., Martin S. Decker, Albany, N. Y.

AMERICAN RAILWAY ASSOCIATION.
Nov. 17. Annual meeting at Chicago, Ill. Secy., W. F. Allen, 24 Park Place, N. Y.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 18-19. Annual meeting at New York City. Secy., W. J. Baxter, 29 West 39th St., New York City.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Dec. 1-3. Annual convention at Milwaukee, Wis. Secy., James C. Monaghan, 20 West 44th St., New York City.

NEW JERSEY SANITARY ASSOCIATION.
Dec. 3-4. Annual meeting at Laurel-in-the-Pines, Lakewood, N. J. Secy., J. A. Exton, 75 Beech St., Arlington, N. J.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Dec. 6. Annual meeting in New York City. Secy., Wm. H. Ross, 154 Nassau St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 7-10. Annual meeting at New York City. Secy., C. W. Rice, 29 West 39th St., New York City.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
Dec. 8-10. Annual meeting at Philadelphia, Pa. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 14-15. Annual meeting at New York City. Secy., Percy H. Wilson, Land Title Bldg., Philadelphia, Pa.

AMERICAN INSTITUTE OF ARCHITECTS.
Dec. 14-16. Annual convention at Washington, D. C. Secy., Glenn Brown, The Octagon, Washington, D. C.

ENGINEERS' CLUB OF ST. LOUIS.—At the regular meeting of Oct. 6, Mr. Wm. H. Bryan presented a paper on "Going Value as an Element in the Appraisal of Public Utility Properties."

BROOKLYN ENGINEERS' CLUB.—At the meeting of Oct. 14, Mr. Geo. L. Knight is to present a paper entitled "The Generating and Distributing System of the Brooklyn Edison Co."

AMERICAN ELECTROCHEMICAL SOCIETY.—The autumn meeting in New York City, Oct. 28-30, will be opened by a professional session in the Chemists' Club on the afternoon of Oct. 28. A number of papers will be presented and Professor Edgar F. Smith, of the University of Pennsylvania, will give a lecture on recent developments in electro-analysis.

The second day will be devoted to an excursion to Bayonne, N. J., where the following plants will be visited: Standard Oil Co.; National Sulphur Co., refining of sulphur; Pacific Coast Borax Co., manufacture of borax and boric acid; Gröndal briquetting plant of the General Chemical Co.; Babcock & Wilcox Co.; Electro Dynamic Co., interpole motors for wide speed variation; Electric Launch Co., submarine vessels; Industrial Oxygen Co., oxy-acetylene welding and cutting apparatus. A banquet will be held in the evening.

On Oct. 30, morning and afternoon sessions for the reading and discussion of papers will be held at Columbia University. The meeting will close with a smoker at the Chemists' Club in the evening.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The 239th monthly meeting of the Institute was held at the Engineering Societies' Building, New York City, on the evening of Oct. 8. Mr. J. B. Taylor, of Schenectady, N. Y., presented a paper, "Telegraph and Telephone Systems as Affected by Alternating-Current Lines." This was a general statement of the combinations of power, telephone and telegraph systems which have been found to give trouble, with descriptions of such remedies or preventives as have been developed. The use of increased resistance and impedence, reversed relay connections and other early "bug traps" for telegraphs were mentioned as palliations only. Where the trouble is of magnitude it is necessary to impose on the telegraph system an equal but reversed alternating voltage in such a way that its variations correspond to those of the original disturbances. In extreme cases this is done by running a new circuit parallel to the ones in trouble and placing in it as often as found necessary a transformer with several secondaries which are inserted reversed in the troubled lines.

In the case of telephone circuits, it was shown theoretically possible to run a closed metallic line through the disturbed fields of an alternating current system and where trouble was found it could be minimized by putting the line in first-class mechanical and electrical condition. Commercial telephone systems were held to have little margin to meet several disturbances as any great change of present telephone currents and voltages on one line would disturb all the neighboring lines and render new standard of construction and operation broadly necessary.

There was a long discussion on the paper, chiefly accounts of specific instances of remedying troubles.